Nvidia Titan X: We review the world's fastest gaming card

CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDWARE, OVERCLOCKING, GAMING & MODDING / ISSUE 158

FULL STEP-BY-STEP GUIDE

BUILD A GREAT GAMING PC FOR £987 INC VAT

PLAY GAMES AT 2,560 x 1,440 FOR UNDER A GRAND

- OVERCLOCKED INTEL SKYLAKE CPU
- NVIDIA PASCAL GRAPHICS
- LIQUID COOLING
- SOLID STATE STORAGE

PLUS

MEMORY SUPER-TEST
12 DUAL-CHANNEL KITS REVIEWED

HOW TO MAKE AN ACRYLIC SIDE PANEL

9 771740 744059 11
NOVEMBER 2016 / £5.99

RAW POWER.
UNCHAINED.

FRAMELESS MECHANICAL GAMING KEYBOARD

Some gamers want all the bells and whistles, whereas gaming purists want raw, undiluted performance. With the Suora, the gaming purists have found their keyboard. The Suora's frameless design channels its philosophy as a pure and efficient mechanical keyboard for no-frills gamers. There's no palm rest, no thick border, no thumb keys, and no unnecessary media keys – just high-quality, solid mechanical keys mounted on a durable plate. It features a robust, compact build with aluminum alloy housing, providing a consistent, distraction-free platform. With key illumination in fan-favorite ROCCAT® blue adjustable in 11 brightness levels, you won't miss a key.

ROCCAT.
SUORA

FRAMELESS MECHANICAL GAMING KEYBOARD

MORE INFORMATION
WWW.ROCCAT.ORG/SUORA

Welcome

Custom PC Issue 158

Editorial

EDITOR
Ben Hardwidge
editor@custompcmag.org.uk

MODDING EDITOR
Antony Leather

GAMES EDITOR
Rick Lane

ART EDITOR
Bill Bagnall
www.billbagnalldesign.com

PRODUCTION EDITOR
Julie Birrell

CONTRIBUTORS
Edward Chester, Gareth Halfacree, James Gorbold, Mike Jennings, Paul Goodhead, Richard Swinburne, Simon Treadaway, Tracy King

PHOTOGRAPHY
Antony Leather, Gareth Halfacree, Mike Jennings

Publishing & Marketing

GROUP PUBLISHER
Paul Rayner
paul_rayner@dennis.co.uk

LICENSING MANAGER
Carlotta Serantoni
Carlotta_Serantoni@dennis.co.uk
+44 (0)20 7907 6550

LICENSING & SYNDICATION ASSISTANT
Nicole Adams
Nicole_Adams@dennis.co.uk
+44 (0)20 7907 6134

SYNDICATION SENIOR MANAGER
Anjum Dosaj
+44 (0)20 7907 6132

Commercial & Advertising

Charlotte Milligan
charlotte_milligan@dennis.co.uk

The paper used in this magazine is produced from sustainable fibre, manufactured by mills with a valid chain of custody.

recycle
When you have finished with this magazine please recycle it.

Dennis

Dennis Publishing Limited

Tel: 020 7907 6000 fax 020 7907 6193

DIRECTOR OF ADVERTISING
Julian Lloyd Evans

MANAGING DIRECTOR DENNIS TECHNOLOGY
John Garewal

CEO
Ian Westwood

NEWSTRADE DIRECTOR
David Barker

FINANCE DIRECTOR
Brett Reynolds

GROUP FINANCE DIRECTOR
Ian Leggett

CHIEF EXECUTIVE
James Tye

COMPANY FOUNDER
Felix Dennis

Subscriptions

You can manage your existing subscription through www.subsinfo.co.uk – this should be your first port of call if you have any queries about your subscription.
Email: custompc@servicehelpline.co.uk

Annual subs: UK £44.99
UK subs: 0844 844 0032

Overseas subs:
Europe £65, ROW £85
Overseas subs: +44 (,0)1795 592 906

LICENSING, REPRINTS, EPRINTS
Wright's Media
0800-051-8327 (toll free)

Printed by BGP

Distributed by Seymour Distribution
020 7429 4001

OVERSEAS NEWSSTAND
Geraldine Grobler, Seymour International Ltd . +44 (0)20 7429 4066

Custom PC is produced by Mr Freelance Limited, and published monthly by Dennis Publishing Ltd, 30 Cleveland Street, London W1T 4JD, a company registered in England number 1138891. Entire contents © Dennis Publishing Ltd licensed by Felden. © Copyright Dennis Publishing Limited. Custom PC is a trademark of Felix Dennis.

DON'T TRY THIS AT HOME The information in this magazine is given in good faith. Dennis Publishing Limited cannot accept any responsibility for loss, disruption or damage to your data or your computer that may occur as a result of following or attempting to follow advice given in the magazine. If things do go wrong, take a break.

Contents

Welcome to Issue 158

86 Build a great gaming PC for under a grand
With a mid-range GPU battle being fought between Nvidia and AMD, and the prices of Intel's Skylake CPUs finally settling down, it's now possible to build a decent gaming PC for a very reasonable price. In fact, as we'll show you this month, it's possible to build a system with an overclocked quad-core Skylake CPU with liquid cooling, an Nvidia Pascal GPU and solid state storage for just £987 inc VAT.

If you're looking to build a decent gaming PC that won't bankrupt you then read on, because this sub-£1,000 PC can tame any game up to a resolution of 2,560 x 1,440, and we'll show you exactly what hardware you need, and how you should go about constructing and overclocking it too.

Highlights

10 Mini-STX is already dead
If you're going to take on mini-ITX, your alternative needs to be flexible, argues Richard Swinburne.

12 Poképhobia Go
Tracy King takes on the BBC's story about links between Pokémon Go and crime.

20 Nvidia Titan X
Can Nvidia's monster new £1,099 graphics card justify its astronomical price?

22 AMD Radeon RX470
AMD's latest GPU aims to capture the sub-£200 graphics card market.

40 2.5in SATA SSDs
They may not have the headline speeds of the latest NVMe drives, but a SATA drive is still a great upgrade from a hard drive. We test nine of them to find out which ones are worth your money.

50 Dual-channel DDR4 memory
We try out six 16GB 2666MHz RAM kits, and six 3000MHz+ kits, to see which memory offers the best bang for your buck in terms of both looks and performance.

96 Hobby tech
Gareth Halfacree looks at maker-friendly laser cutters, underwater robots and the new Genuino Zero.

104 Make an acrylic side panel
Want your side panel to show off the full extent of your PC building skills? Antony Leather shows you how to create a see-through one.

Regulars

8 From the editor
10 Richard Swinburne
12 Tracy King
14 Incoming
16 Letters
34 Custom kit
38 How we test
66 Elite products
77 Inverse look
84 The engine room
96 Hobby tech
101 RealBench leaderboard
102 Customised PC
104 How to guides
109 Your folding milestones
110 Readers' drives
114 James Gorbold

Cover guide

Reviewed this month

42 PRODUCTS REVIEWED

Reviews

CPU COOLER
19 Phononic Hex 2

GRAPHICS CARDS
20 Nvidia Titan X
22 Asus Strix Gaming Radeon RX470 4GB

ATX CASES
24 Be Quiet! Dark Base Pro 900
26 Corsair Carbide Air 740

MOTHERBOARD
30 MSI Z170A MPOWER Gaming Titanium

GAMING LAPTOP
32 XMG P507

Custom kit

34 Harman Kardon Go + Play
34 Libratone One Click
34 Star Wars Art Therapy Colouring Book
35 Sphero SPRK+
35 Dyson Supersonic
35 Sandberg Gel Mousepad Wrist + Arm Rest

2.5in SATA SSD Labs

41 Crucial MX300 525GB
41 Crucial MX300 1TB
42 Kingston UV400 480GB
43 Samsung 750 Evo 500GB
44 Samsung 850 Evo 120GB
44 Samsung 850 Evo 500GB
46 Samsung 850 Pro 256GB
46 Samsung 850 Pro 512GB
47 SanDisk Extreme Pro 480GB

16GB dual-channel 2666MHz DDR4 RAM Labs

51 Avexir Impact
51 Corsair Vengeance LPX
52 Crucial Ballistix Tactical
52 G.Skill Ripjaws V
53 Geil Dragon RAM
53 HyperX Savage Black

16GB dual-channel 3000MHz+ DDR4 RAM Labs

56 Corsair Vengeance LED
56 Crucial Ballistix Tactical
57 G.Skill Trident Z
57 Geil Dragon RAM
58 Patriot Viper Elite Series
58 Team Group Dark Pro

PC system reviews

60 CyberPower Hyper Liquid 100
62 Chillblast Fusion Platinum
64 Scan 3XS X99 Carbon X SLI

Games

78 No Man's Sky
80 Abzû
80 Inside
82 Quadrilateral Cowboy

Hobby tech

100 Genuino Zero

Windows 10

CyberPowerPC recommends Windows.
One experience for everything in your life.

Infinity Xtreme Pro

Windows 10 Home

Intel® Core™ i7-6900K Processor
ASUS® X99-A Mainboard
16GB DDR4 3000mhz Corsair Vengeance LPX Memory
480GB Kingston UV300 SSD
2TB SATA III 6.0Gb/s 64MB HDD
8GB MSI Nvidia® GeForce® GTX 1080 Video Card
16X LG® Blu Ray BH16NS40 Writer Black
CoolerMaster Staker 935 Gaming Case
CoolerMaster B600 Power Supply
Cyberpower Advance Water Cooling system
Extreme Overclocking
LCD monitor is not included but optional

16x Optical Drive | HD 7.1 | CoolerMaster® | CoolerMaster®

FROM **£2629**

Liquid Cooling **Included**

Infinity Xtreme

Windows 10 Home

Intel® Core™ i7-6800 Processor
MSI® X99A RAIDER Mainboard
16GB DDR4 3000mhz Corsair Vengeance LPX Memory
240GB Kingston UV300 SSD
2TB 7200rpm SATA III 6.0Gb/s 64MB HDD
8GB MSI Nvidia® GeForce® GTX 1070 Video Card
NZXT H440 Gaming Case
Corsair CX600 Power Supply
Corsair H55 Cooling System
LCD monitor is not included but optional

Liquid Cooling Included | FROM **£1575**

HD 7.1 | CoolerMaster® | CoolerMaster®

Infinity X55

Windows 10 Home

Intel® Core™ i5-6600K Processor
Gigabyte Z170-HD3 Mainboard
8GB DDR4 2400mhz Corsair Vengeance LPX Memory
2TB 7200rpm SATA III 6.0Gb/s 64MB HDD
2GB MSI Nvidia® GeForce® GTX 960 Video Card
NZXT Source 340 Mid Tower Black
Corsair VS 450W Power Supply
Corsair H55 Cooling System
LCD monitor is not included but optional

Liquid Cooling Included | FROM **£885**

HD 7.1 | CoolerMaster® | CoolerMaster®

Order your ultimate gaming system today! **www.cyberpowersystem.co.uk**

All Desktop systems come with 3 year Limited Warranty + lifetime toll free techsupport

CyberPowerPC, CyberPowerPC Logo and, Unleash The Power are trademarks of CyberPower Inc. Copyright © 2013 CyberPower. All rights reserved. All prices are subject to change without notice or obligation. Celeron, Celeron Inside, Centrino Inside, Centrino Logo, Core Inside, Intel, Intel Logo, Intel Core, Intel Inside, Intel Inside Logo, Intel Viiv, Intel vPro, Itanium, Itanium Inside, Pentium, Pentium Inside, Viiv Inside, vPro Inside, Xeon, and Xeon Inside are trademarks of Intel Corporation in the U.S. and other countries. All prices are subject to change without notice or obligation. CyberPower is not responsible for any typographical or photographic errors. NVIDIA®, nForce®, GeForce®, SLITM are trademarks or registered trademarks of NVIDIA Corporation or its subsidiaries in the United States and other countries. CyberPower PCs use genuine Microsoft® Windows®. www.microsoft.com/piracy/howtotell

Intel Inside®. Amazing Experience Outside.

LIQUID COOLING INCLUDED

CPUs with standard fansinks can reach core temperatures as high as 130°C, however, liquid cooling can lower that to 59°C giving you better performance and longer lifespan on your CPU.

£54.99 VALUE

Infinity X33

Liquid Cooling Included

FROM **£655**

Windows 10 Home

Intel® Core™ i3-6100 Processor

MSI B150M PRO-VDH Mainboard
8GB DD4 2133mhz Kingston Value Memory
1TB 7200rpm SATA III 6.0Gb/s 64MB HDD
2GB Nvidia® GeForce® GTX 950 Video Card
CoolerMaster Elite 310 Mid-Tower Case
Thermaltake Litepower 350W Power Supply
Corsair H55 Cooling System
LCD monitor is not included but optional

DVD			
24X DVD ±RW	HD 7.1	CoolerMaster®	CoolerMaster®

Infinity X77

Liquid Cooling Included

FROM **£1175**

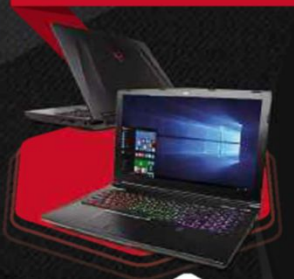
Windows 10 Home

Intel® Core™ i7-6700K Processor

ASUS® Z170-P Mainboard
8GB DDR4 2400mhz Corsair Vengeance LPX Memory
120GB Kingston UV300 SSD
1TB 7200rpm SATA III 6.0Gb/s 64MB HDD
4GB MSI Nvidia® GeForce® GTX 970 Video Card
Corsair 450D Gaming Case
CoolerMaster B600 Power Supply
Corsair H55 Cooling System
LCD monitor is not included but optional

DVD			
24X DVD ±RW	HD 7.1	CoolerMaster®	CoolerMaster®

Fangbook 4 SX6-100



15.6"HD

FROM **£789**

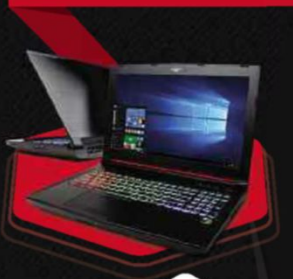
Windows 10 Home

Intel® Core™ i7-6700HQ Processor

15.6" Full HD 1920 x 1080 Display
Intel HM170 Express Chipset
Nvidia® GeForce® GTX 960M 2GB Video Card
4GB DDR4 2133MHz HyperX Impact Black Memory
500GB 5400RPM SATA HDD
Intel® Dual Band Wireless-AC 3165 WiFi
Bluetooth 4.0 Combo

DVD			
8X DVD ±RW	180 Mins	Bluetooth 4.0	2x USB 3.0 1x 3.1 Type C
1x HDMI Port	Built-in 720P HD Webcam	2.4 kg	AC WiFi

Fangbook 4 Xtreme G-Sync 200



15.6"HD

FROM **£1609**

Windows 10 Home

Intel® Core™ i7-6700 Processor

15.6" UHD 3840 x 2160 Display
Intel Z170 Express Chipset
Nvidia® GeForce® GTX 980M 8GB Video Card w/G-Sync
16GB DDR4 2133MHz SODIMM memory
2TB 5400RPM SATA HDD
240GB SM2280 S3 M.2 SSD
Intel® Dual Band Wireless-AC 8260 WiFi
Bluetooth 4.0 Combo

250 Mins	Bluetooth 4.0	3x USB 3.0 1x 3.1 Type C
1x HDMI Port	Built-in 720P HD Webcam	2.4 kg	AC WiFi

CYBERPOWERPC
UNLEASH THE POWER

ORDER TODAY! **0844 371 2727**
www.cyberpowersystem.co.uk

Cortana available in select markets at launch, experience may vary by device.
*External monitor must support HDMI Input (If continuum-compatible accessory is not included, add: *Accessories sold seperately.*) **App availability and experience varies by device and market. Office 365 subscription required for some features. 1Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

Work easy. Play hard. Windows

BEN HARDWIDGE / FROM THE EDITOR

THE GRAPHICS MEMORY RIP-OFF

Ben Hardwidge asks why graphics card manufacturers are so keen to stick far more memory than we need on their PCBs

There are lots of ridiculously big numbers associated with Nvidia's new Titan X graphics card (see p20). It's difficult to comprehend that there are 12 billion transistors busily switching on and off inside the GPU, and it's similarly tough to get your head around the £1,099 asking price. However, the number that really stood out as over the top when I first saw it was a simple 12 – the number of gigabytes of memory stuck onto the Titan X's PCB.

I've never liked the phrase 'less is more', mainly because it's the sort of phrase people use to tell me why the gratuitously technical music I like isn't very good, but in this case it's true that 'less is fine' and that 'more is a silly waste of money'. There may well be a case for using 12GB of graphics memory for raw compute power, rather than gaming, but let's not pretend that it won't be used as a marketing tool for gamers too.

Out of curiosity, while testing the Titan X, I decided to monitor its usage of the graphics memory. Historically, graphics cards with more memory have been better at running games at higher resolutions, and handling lots of anti-aliasing better than cards with less memory. More memory can also be good for handling large, high-resolution textures. So I ran The Witcher 3 at its top settings – that's Ultra detail, HairWorks enabled with full anti-aliasing, 4K resolution – the lot (and it looks amazing at these settings). Throughout play, the memory usage, which I monitored using GPU-Z, peaked at 2,791MB – it didn't even need 4GB, let alone 12GB.

To get a bit of context, I then ran our usual Unigine Valley stress test at 2,560 x 1,440, and the memory usage didn't even go over 1GB. I've often said that the amount of memory slapped on graphics cards to get the numbers up is more than necessary, but I didn't realise quite how much.

> I ran our usual Unigine Valley stress, and the memory usage didn't even go over 1GB

In truth, I'm not really that annoyed about the Titan X's 12GB of memory. It's a ludicrously overpriced graphics card for people who want the fastest components, regardless of the price – if you can afford £1,099 for a graphics card, I doubt you're worried about getting peak value for money. What's more irritating is the industry's obsession with putting more memory than you need on cheaper, mid-range graphics cards.

AMD's Radeon RX480 8GB and Nvidia's GTX 1060 6GB are prime examples. These cards aren't built to run games at 4K with loads of anti-aliasing; they're built for 2,560 x 1,440 gaming at most, yet they come with memory that wouldn't even be used at the former settings. People will mistakenly think they need the 8GB RX480 card over the 4GB version to get the best performance, but that extra memory won't get used in games at 2,560 x 1,440 in the card's lifespan. After some price increases since it first launched, the Radeon RX480 8GB is now uncompetitive, but the 4GB cards are nowhere to be seen, yet they'd likely be award winners if we reviewed them.

It's understandable that graphics card marketing teams focus on memory. It's easier to sell the number of gigabytes of memory than discuss the width of the memory bus or the stream processors. You can just put the number on the box without explanation. It's just frustrating that the prices of these cards are being bumped up to the point where they're no longer competitive, for the sake of bigger, meaningless numbers. CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk @custompcmag

GLADIATOR COMPUTERS

4 Years Warranty | Flexible Customisation | Finance Available

AWARD WINNING GAMING PCS

SNIPER GAMING PC

: INTEL Pentium G4400 3.30GHz Dual Core Processor
: NVIDIA GTX 950 XTREME 2GB Graphics Card
: 4GB DDR4 2133MHz Memory
: 1TB SATA III Hard Drive

FROM £409.99

APOCALYPSE GAMING PC

: INTEL i5-6400 2.70GHz Quad Core Processor
: NVIDIA GTX 970 4GB Graphics Card
: 8GB DDR4 3000MHz Memory
: 1TB SATA III Hard Drive

FROM £769.99

BATTALION 800 GAMING PC

: INTEL i5-6500 3.20GHz Quad Core Processor
: NVIDIA GTX 970 4GB Graphics Card
: 16GB DDR4 2133MHz Memory
: 120GB SSD + 1TB SATA III Drive

FROM £925.00

ALPHA 1080 GAMING PC

: INTEL i5-6600K 3.50GHz Quad Core Processor
: NVIDIA GeForce GTX 1080 8GB Graphics Card
: 16GB DDR4 3000MHz Memory
: 128GB M.2 NVMe SSD

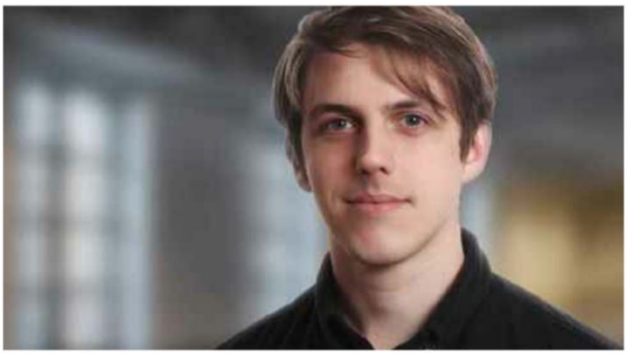
FROM £1299.95

GLADIATOR COMPUTERS

£15.00 OFF Your custom build gaming PC when you use this discount code **:D0313**

For great prices & service on Accessories / Computer Components visit our sister site **www.aria.co.uk**

0161 248 1618 | sales@gladiatorpc.co.uk | www.gladiatorpc.co.uk | Join us on



RICHARD SWINBURNE / VIEW FROM TAIWAN

MINI-STX IS ALREADY DEAD

If you want to create an alternative to mini-ITX, it needs to be flexible, argues Richard Swinburne

Custom mini PCs have been gaining a large following, as people swap their ATX gear for small form factors that deliver more variety and challenge. Mini-ITX – introduced by VIA in 2001 – has gone from a niche, underpowered form factor to a full, top-to-bottom market segment in the past five years. The ecosystem around it has flourished with new complementary products, such as SFX PSUs, low-profile coolers, small graphics cards and even a small form factor liquid cooler from Corsair. Then there are the dozens of different and sometimes experimental mini-ITX chassis (the NCase M1, for example) that provide some excitement that a bog-standard ATX build sorely lacks.

However, at the expense of mini-ITX's success, we've lost FlexATX (by Intel in 1999) and mini-DTX (proposed by AMD in 2007). Both these ideas would have given us a little more expansion room from two PCI-E slots, and while you get the occasional motherboard in these form factors, it was micro-ATX that largely filled this gap.

In recent years, PCs have been getting even smaller than mini-ITX machines, giving a breath of life into the ailing pre-built PC industry, and many traditional motherboard and PC manufacturers have created a variety of little offerings. Arguably, the most successful – or attention-grabbing – is Intel's NUC series that shoehorns its U-series mobile chips into tiny boxes. While I raged at the recent Skull Canyon version in Issue 153, generally the NUC series gets it right, offering high-quality, capable and low-noise machines for office and home use – they're ideal for anyone who doesn't play games, or undertake CPU-intensive work, but still needs a PC.

> You can't even add a flexible PCI-E riser to flip a card underneath the board

However, the NUCs and their like lack the breadth of CPU choice a socket provides, so Intel recently proposed the mini-STX form factor. With a 127 x 127mm PCB size, it shaves off several centimetres from a mini-ITX board, while keeping the replaceable CPU socket, which means you can drop any LGA1151 CPU you like into it. Unfortunately, though, shaving 50mm off each side of the motherboard introduced a mountain of problems, so mini-STX never took off.

Firstly, since the front I/O panel is integrated into the motherboard, you can only buy the motherboard with a matching chassis, removing your ability to mix and match parts. Secondly, there's no 16x PCI-E slot, so even if you wanted to add a flexible PCI-E riser to flip a card underneath the board, and try to make an interesting mini-gaming build, you can't do it. Next, the only mini-STX board available – the ASRock H110M-STX – has no heatsink on the H110 PCH. Its exposed core directs its 6W of heat into the PCB, or the M.2 SSD that sits on top of it. The idea is that the CPU cooler will push air over it, but that's another issue, leaving little in the way of options for third-party coolers.

All of these issues makes mini-STX practically pointless (much like SATA Express, as I said in Issue 142); there's already a variety of mini PCs available to satisfy the non-enthusiast market. I'd even say that very few people buying these kinds of mini PCs really care about an absolute CPU spec either. Performance PC enthusiasts will want to choose their chip down to the nth degree, and if they want that level of flexibility, they'll go for mini-ITX. Mini-STX has simply too many limitations to make it even a consideration, which is a shame. EPC

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

CORSAIR

LAPDOG

LIVING ROOM GAMING
WITH ZERO COMPROMISE

Bring the ultimate 4K gaming experience to the living room – with the portable gaming control center that brings precision desktop gaming performance to your couch.

LEGENDARY CORSAIR PRECISION

FROM THE COMFORT OF YOUR COUCH

All your gaming gear connected right where you are. Everything you need in a perfectly balanced, ergonomic gaming setup. Precise keyboard control. Generous mouse pad area. No compromises.

**Sold without Keyboard and Mouse*

VORTEZ GOLD

GAMERS CHOICE AWARD

WWW.OVERCLOCK3D.NET GAMERS CHOICE

KITGURU WORTH BUYING

LEARN MORE AT
corsair.com
/LAPDOG

/corsair.com

TRACY KING / SCEPTICAL ANALYSIS

POKÉPHOBIA GO

If you're going to connect Pokémon Go to crime, you'll need better evidence than the BBC is offering, argues Tracy King

If you live under a rock you'll still be aware of Pokémon Go, because hordes of players will have been hanging around your rock trying to catch a Geodude. However, one annoying effect of a game becoming such a huge social phenomenon is that the mainstream media feels obliged to report on it, and either get facts wrong in a hilarious trying-to-be-cool way, or get facts wrong in an un-hilarious thinking-new-things-are-inherently-bad kind of way. Regular readers will already know that the latter type of reporting is my biggest bugbear (Bugbear isn't, sadly, a type of Pokémon), and I'm quite simply not having it.

Where there's technology, there are naysayers, technophobes and click-hungry news outlets. Self-driving cars are going to kill us all if we go outside, and we already know that video games cause serial killers/terrorism/teenage pregnancy if we stay inside, so it was only a matter of time before a game neatly intersected these two horrors on the media's radar and someone wrote about how going outside to play a video game is bad. The someone in this case is the BBC, which is surprising, as it isn't usually on my list of lazy media. A bright spark at the BBC decided to send a Freedom of Information request to various police bodies asking about crime relating to Pokémon Go.

The data came back and, not surprisingly (given the game has over five million players in the UK alone), there have indeed been Pokémon Go related police reports.

The police, in a move I like to call 'obeying the law', didn't release details of the reports beyond vague descriptions, which immediately highlights the inherent problem with this type of journalism. We have no way of knowing if the words 'Pokémon Go' were recorded in the crime report as a negative element, a positive element, an incidental aside or indeed whether any crime was committed.

> The police, in a move I call 'obeying the law', didn't release details

Just about every news outlet picked up on the non-story, from tabloids to gaming sites to broadsheets, and all repeated vague anecdotes, such as 'a woman contacted police claiming Pokémon Go characters were trying to get into her home'. What of it? Was she mistaken and it was a burglar? Was she old and confused? Did she have a history of calling police with weird sightings?

This story tells us nothing whatsoever about Pokémon Go's effect on society because there simply isn't any information there. But the media coverage delighted in suggesting that Pokémon Go is responsible for a massive crime wave, despite there being zero evidence that's the case. Someone got mugged while out playing the game, but they may have only mentioned to the police that they were playing it because it's new. Everyone else who got mugged might not have bothered mentioning what they were doing on their phone at the time.

Without also asking for records of crimes featuring, say 'Twitter' or 'Minecraft' or 'texting', we don't know whether these reports represent anything beyond the game going from not existing to existing. We don't know whether these reports represent an increase in crime or not. Responsible reporting would compare the 290 Pokémon Go incidents recorded in July by England and Wales police to something else. The number is useless by itself. Without context, you don't know if it's part of a trend, or bigger or smaller than another number – it's just a random floating number that's being reported in order to pique everyone's interest in the hope they'll click. Actually, that sounds a bit like my Pokémon ... CPC

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdoll

A million computers are waiting to be built.

DARK BASE 900

There may be countless ways to build a PC. But there´s one series of PC cases that makes them all possible: Dark Base 900. It offers maximum flexibility to suit your individual space requirements. And of course, it´s one of the quietest cases in the world, featuring:

- Repositionable motherboard tray and HDD tray with the option of inverse layout
- Three virtually inaudible be quiet! SilentWings® 3 PWM fans
- Full-circuit airflow system with noise-dampened vents
- Four areas for water cooling radiators up to 420mm
- Dark Base Pro 900 with LED illumination, window with tempered glass and wireless Qi charger

For more information visit bequiet.com

GERMANY'S NO. 1* PSU MANUFACTURER

*GfK data 2016

Available at: scan.co.uk · overclockers.co.uk · ebuyer.com · aria.co.uk · amazon.co.uk

be quiet!®

Incoming

We take a look at the latest newly announced products

Corsair announces Lux keyboards

Corsair's K70 RGB Rapidfire (see Issue 154, p21) proved that Corsair hadn't abandoned the metal chassis and premium build quality that made its K-series mechanical keyboards so great, and now the company has launched a whole new range of Lux-branded keyboards, which bring the design into the modern era. The new keyboards will have an aircraft-grade aluminium chassis, and sport the media controls found on the older K-series keyboards, but will also come equipped with an enhanced lighting controller, to give you finer control over the colours and patterns produced by the backlight LEDs. The Lux keyboards will also feature a larger font on the keys, and a range of lighting options and switch types will be available.

AMD unveils Zen details

AMD's new Zen CPU architecture isn't due to ship until next year, but AMD has already lifted the lid on some details. In a presentation, the company claimed Zen would increase the number of instructions per clock (IPC) by 40 per cent in comparison to its current 'Excavator' CPUs. Using 14nm FinFET transistors, the new chips promise improvements to the cache system and a superior branch prediction system to current AMD CPUs.

There are still some similarities with current AMD chips, though, including the split of integer and floating point units. Rather than having an integer unit (IU) and floating point unit (FPU) per core, like Intel's CPUs, Zen will feature one FPU per two integer units. AMD outlined an example with four IUs, two FPUs and a shared 16-way 8MB of L3 cache, along with 512KB of 8-way L2 cache, all arranged in slices so that each core can effectively access any part of the cache with the same latency. AMD also says Zen will be able to execute two threads per core, which Intel currently achieves with its Hyper-Threading technology.

Lots of the individual parts have been improved. AMD says there will be 192 instruction schedulers in the IUs, for example, compared to 128 in current AMD CPUs. Likewise, the CPU will also be able to load to the quad-issue (four pipes) FPU quicker, taking seven clock cycles rather than nine. Meanwhile, AMD says the new chips will feature 'aggressive clock gating' to improve the performance per watt.

Nvidia launches cut-down GTX 1060

In a move that's bound to cause some confusion, Nvidia has launched a new version of the GeForce GTX 1060 with fewer stream processors and less memory on the cards. The new GPUs have 1,152 stream processors, rather than the 1,280 found on their bigger siblings. They also come with 3GB of memory as standard, rather than the 6GB found on the pricier cards.

At stock speeds, the new cards will have the same 1506MHz clock speed (1708MHz boost) as the 6GB cards, and they also have the same 8GHz (effective) GDDR5 memory frequency and 192-bit wide memory interface. GeForce GTX 1060 3GB cards currently start at £189 inc VAT from **www.scan.co.uk**

No AMD Vega GPUs until 2017

After recently launching its very respectable line-up of mid-range Polaris GPUs, many enthusiasts were hoping we'd be seeing AMD's high-end Vega GPUs soon too. However, in an August presentation to investors, AMD stated that its forthcoming Vega GPUs wouldn't be released until the first half of 2017. Like Polaris, Vega will be built on a 14nm node, and is expected to make use of high-bandwidth memory 2 (HBM2), much like the current Fury and Fury X cards use first-generation HBM, building the memory into the same package as the GPU, which saves on PCB space and reduces latency.

OVERCLOCKERS UK
www.overclockers.co.uk

AWARD WINNING PCS • 3 YEAR WARRANTY ON ALL OF OUR SYSTEMS • FEATURING GTX 10 SERIES CARDS

- Intel® Core™ i7-6700K Processor
- Z170 Motherboard
- Up to 16GB 3200MHz DDR4 Memory
- Samsung NVMe/SSD/Seagate HDD
- 80+ Gold Rated PSU
- GeForce GTX 1080
- Custom Watercooling

GET A GAMING PC TO SUIT YOUR BUDGET WITH THE NEW NVIDIA GEFORCE GTX 1060, 1070 & 1080 GRAPHICS CARDS!

INTEL INSIDE.®
EXTRAORDINARY PERFORMANCE OUTSIDE.

TITAN NEUTRON
AVAILABLE WITH I5 & NVIDIA GTX 1060 GPU

TECHLABS CHAMELEON
AVAILABLE WITH I7 & NVIDIA GTX 1080 GPU

TITAN BAYONET
AVAILABLE WITH I5/I7 & GTX 1060/1070/1080

TITAN FORCEBOX VR10
AVAILABLE WITH I3/I5 & GTX 1060/1070/1080

WWW.OVERCLOCKERS.CO.UK // TEL: 01782 44 44 55

Overclockers UK | Unit 5 Lymedale Cross, Newcastle-under-Lyme, Staffordshire, ST5 9BT

Letters

Please send us your feedback and correspondence to letters@custompcmag.org.uk

Bring on the PC evolution

Richard Swinburne's article regarding PC evolution in Issue 157 was right on the mark. I think the time has come for the industry to agree on the next generation of motherboards and solve the issues identified. There's an opportunity to design something completely fresh, tidying up the way in which cables attach to motherboards and graphics cards, while standardising sockets, removing old (or poorly supported) technology and improving airflow.

Moving on from the ATX format might be a challenge, but it's not impossible; for years we've had to renew motherboards when processors, memory and graphics cards evolve. This time we might have to buy a new case as well. I would look forward to a new evolution of the PC – if the industry could agree on a way forward, there would be an opportunity for everyone to cash in.

MARK GARDNER

Ben: Thanks for your feedback, Mark. Rich does make a number of good points in that column. I'm amazed we're still tolerating so much of the detritus from the PC's legacy.

Frames of war

Ben makes a great and interesting point about frame rates. I've always found that, fundamentally, the minimum and maximum are the most important figures. I remember owning an AMD Radeon HD 4850X2, and I was very happy to say I had a dual-GPU card at the time. However, the more I looked into it, I found my card was hitting the dizzy heights of 160fps in Call of Duty: World at War, but dipped at a real low of 28fps when action became very frantic on screen. During these lows, I found the frame rate difference was the difference between living and dying in a competitive online shooter.

However, I found that updating the drivers for my graphics card over its life cycle dramatically raised the minimum frame rate, but not so much the maximum. I believe that more emphasis should be put on the maximum and minimum, rather than the average.

MARTIN HARTSHORN

Ben: Yes, the minimum is by far the most important frame rate metric for me. The maximum gives you a good peak figure, but it's the minimum that you really notice when your game slows down.

New gear's resolutions

I enjoyed your recent monitor roundup, and noted in particular your choice for AMD card users, which I will purchase in my next upgrade cycle. As part of that cycle, I always assumed that I would consider changing from my present 1,920 x 1,080 monitor to a 2,560 x 1,440 monitor, as 4K holds very little interest for me at the moment.

Windows 10 enables you to scale up the Windows desktop so that icons and text aren't unusably small at higher resolutions

However, it suddenly occurred to me that, at my age, with my eyesight becoming less keen than previously, such a move might prove counterproductive, which is why I would appreciate your guidance. A 2,560 x 1,440 screen would give me the benefit of more pixels, and let me fit more on the screen, but of course, everything on the screen would be far smaller, and thus harder to see.

Can you scale up objects on these screens to make them easier to see in Windows 10? Can 2,560 x 1,440 screens display a picture at 1,920 x 1,080? Should I just stick with my present resolution? I will definitely be increasing my screen size from 24in to 27in, but I can't decide on the resolution. What would be the advantages, for me, if any, of moving up to 2,560 x 1,440?

RICK BILLSON

Ben: There are a few factors to consider here, Rick. The first is that the pixels on a 27in monitor will be larger than the pixels on a 24in monitor with the same resolution. We refer to this metric as the pixel density, which is usually measured in pixels per inch (ppi). A higher ppi means the image looks smoother to your eye, with less obvious pixels, but it will reduce the size of objects such as text and icons on the Windows desktop (I'll come to Windows 10 scaling in a bit).

A typical 24in 1,920 x 1,080 panel has a pixel density of around 92ppi, which would increase to around 122ppi if you increased the resolution to 2,560 x 1,440. However, by moving up to a 27in screen, the pixel density of a 2,560 x 1,440 resolution would effectively drop to around 108ppi because of the larger screen area.

So, at their default settings, icons text and so on would appear smaller on a 27in 2,560 x 1,440 27in display than on a 24in 1,920 x 1,080 screen.

> Moving on from the ATX format might be a challenge, but it's not impossible

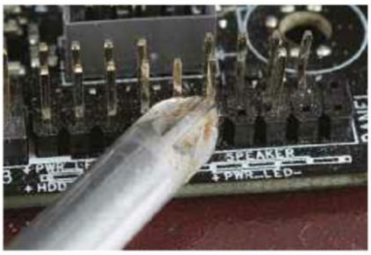
Windows 10 does have some good scaling options to counter this effect, though, and it scales much better than previous versions of Windows, making text and icons look sharp without them being unreadable – you can control the amount of scaling you want too. The only downer is that some software still doesn't scale properly, and ends up either looking too small (such as older versions of Photoshop), or it ends up looking fuzzy (such as iTunes). I use a 27in 4K monitor with Windows 10 scaling, though, and like it much more than my old 26in 1080p monitor – the image is so much smoother and more detailed.

Finally, I'd avoid dropping the resolution of a 2,560 x 1,440 monitor down to 1,920 x 1,080 if it's at all possible. By their nature, LCD panels are digital, rather than analogue, so they have a native resolution at which the image looks sharp. A 2,560 x 1,440 monitor will drop down to 1,920 x 1,080, but it will have to compensate for the pixels being the wrong size for the panel, and will end up looking fuzzy.

Screwed up

Oh dear, oh dear. In your article in PC building, you mention that you require a Phillips crosshead screwdriver – to be precise, you'll need primarily a #2 Phillips screwdriver, and you may also need a #1 for changing expansion card brackets. However, however my Asus M2 screw is even smaller and needs a #0 screwdriver, and then to cap it all, in picture 22, in glorious colour, is a very grubby Pozidrive #2 which won't fit anything except the odd European cooling component.

HUGH TATTERSALL



This is not a #2 Phillips screwdriver

Ben: Oh damn, I thought we'd got away with that! This is the downside of trying to find exactly the right tools in the Dennis lab when you only have a certain amount of time for a photo shoot. You're absolutely right, although in my defence, picture 22 does only show me shorting out the power pins on the motherboard, which a Pozidrive #2 screwdriver will do pretty much as well as any other screwdriver. CPC

Twitter highlights

Follow us on Twitter at @CustomPCmag

EckhardMahne Hello, any chance of reviewing 2K/4K monitors without G-Sync or FreeSync? They're luxuries that not everyone can afford :(
Ben: Yep, it's on the list of future Labs tests. Watch this space.

PCEnthusiastUK Yay! Exceeded the score of 8,000,000 points @ CustomPCMag – Electricity costs are spiralling no doubt, but @foldingathome is a worthy cause.

DomMoass Interesting you suggest GTX 1060 is aimed at 1440p gaming. What is GTX 1070's ballpark then, as it can't quite do 4K gaming?
Ben: The GTX 1070 can do some 4K gaming, but it struggles in some games at top settings, which does put it in a weird limbo. There are resolutions between 2,560 x 1,440 and 4K, though, particularly on ultra-widescreen displays, such as 3,440 x 1,440, which the GTX 1070 can likely handle much better.

Lincoln_Ess Being a rookie to this PC building stuff; this is going to be a great help. Thanks @ CustomPCMag

Ben: You're very welcome!

Johnty14 The holibob is here and 7 months of hard graft have paid off! I nearly gave in but....#IDidntRead1!

Ben: Wow, that's some good reading material you have there – hope they didn't take you over your luggage allowance.

wellrandom Loving @ CustomPCMag PC building piece. On my first build, I had no idea what standoffs were for, so fixed direct to mobo tray! Worked tho :) One missed trick in the piece – magnetise your screwdriver. Dead handy when trying to screw in tight spaces.
Ben: That was a close one with your motherboard – I've seen too many fried motherboards from that mistake over the years! And yes, a magnetic screwdriver can be very handy.

vimeous Some great articles this month – so many gfx choices and some very nice cases.
Ben: Glad to be of service!

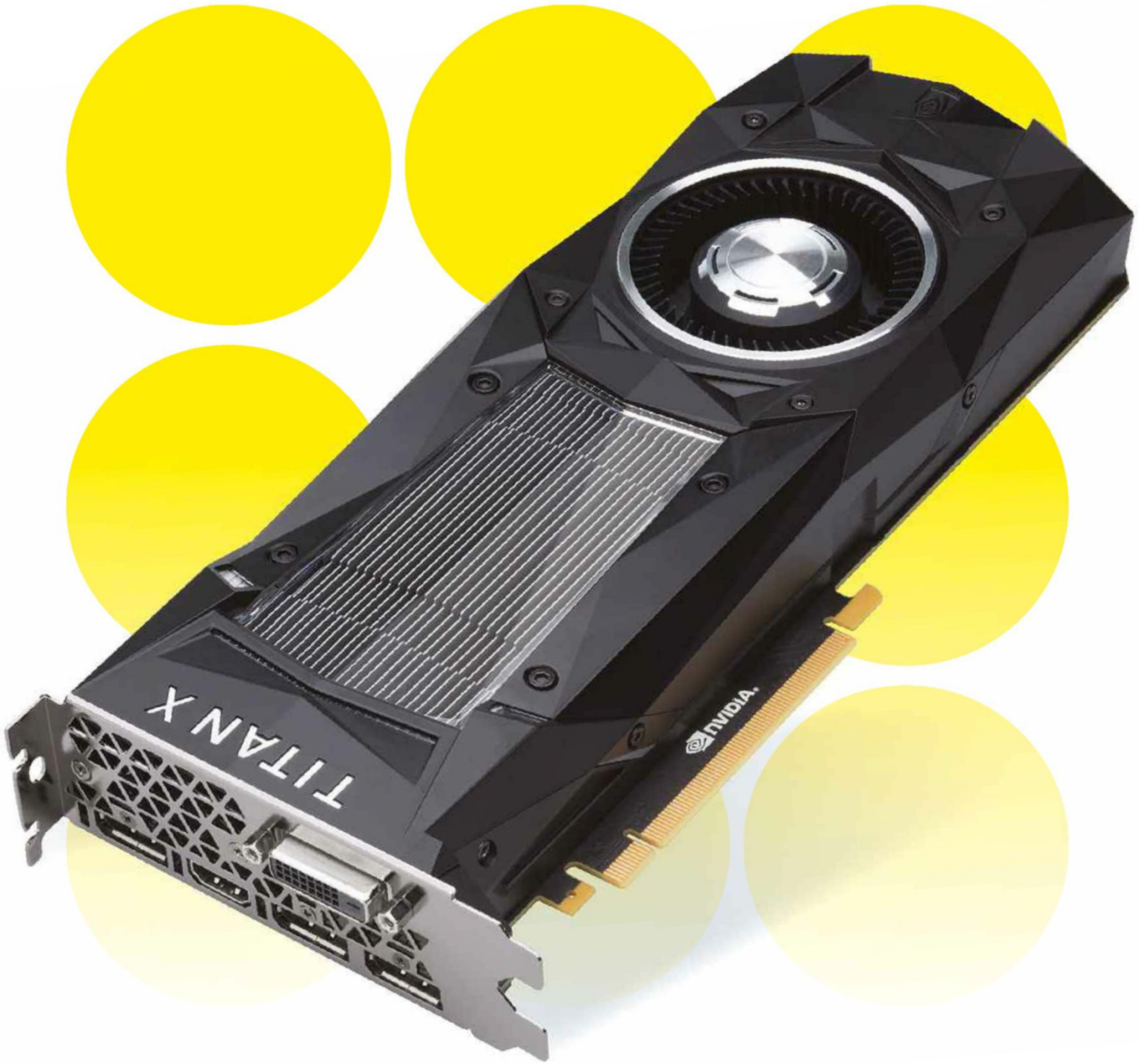
WHEN'S THE NEXT MAG COMING OUT?
Issue 159 of Custom PC will be on sale on Thursday, 13 October, with subscribers receiving it a few days beforehand.

OCT 13

Send your feedback and correspondence to letters@custompcmag.org.uk

Reviews

Our in-depth analysis of the latest PC hardware



Reviewed this month

Phononic Hex 2 p19 / Nvidia Titan X p20 / Asus Strix Gaming RX470 4GB p22 /
Be Quiet! Dark Base Pro 900 p24 / Corsair Carbide Air 740 p26 /
MSI Z170A MPOWER Gaming Titanium p30 / XMG P507 p32 / Custom kit p34

HOW WE TEST
PAGE 38

CPU COOLER

Phononic Hex 2 / £110 inc VAT

SUPPLIER www.overclockers.co.uk

Unlike your average compact 92mm air cooler, the Phononic Hex 2's has a 35W thermoelectric cooler (TEC) embedded in the base, which is powered by a 6-pin PCI-E connector on the side of the heatsink. The TEC part passes a current through a semiconductor, which gets cold on one side and hot on the other, thanks to the Peltier effect. The Hex 2 is basically designed to offer all-in-one (AIO) liquid cooler performance in a compact 92mm heatsink.

There's a 35W thermoelectric cooler (TEC) in the base

Of course, condensation is an issue when you cool a device below ambient room temperature, but the cooler's Standard mode enables on-board temperature sensors to limit the TEC's power, preventing the base from becoming too cold, avoiding condensation and only ramping up to full cooling power when the CPU is under load. When the TEC isn't enabled, the unit relies on an internal 92mm fan, heatsink and heatpipes. Other modes are selectable in the Hex 2's software suite, which connects to the cooler via USB, and also gives you control over the LED colours.

Insane mode applies full TEC power at lower temperatures, and the delta T dropped by 5°C when idle as soon as we enabled this mode. However, Phononic warns against using the Insane mode in temperatures above 25°C to avoid condensation – a High Ambient mode is for available these situations. Finally, the Smart Set mode lets you customise these settings for your own environment – as every place is different, we've just tested the Insane and Standard modes.

The cooler itself is compact and very well made, plus it's easy to install with a simple backplate and CPU side mounting plate. The PCI-E power connector may not fit between the cooler and your graphics card, though, so you might need to rotate the heatsink 108 degrees so that the cable points upwards. Meanwhile, the fan has a 4-pin header and is controlled by your motherboard.

The cooler isn't particularly quiet at full speed, but the fan isn't as loud as most AIO liquid coolers we've heard. With the fan at lower speeds, though, it's close to silent and easily a match for Noctua's similarly sized NH-D9L. The TEC certainly helped the Hex 2 to better the Noctua too – by 3°C on our LGA1150 rig and 4°C on our LGA2011 system. It came close to bettering Corsair's H75 too – amazing for such a small cooler.

The Phononic HEX 2 performs better than equivalently sized air coolers, it keeps pace with AIO liquid coolers and it's simple to use, although it's also distinctly niche. Noctua's NH-D9L offers much better value for money for small overclocks, but if you need more cooling power in a tight space, and an AIO cooler won't fit, the Hex 2 is a great if pricey option.

ANTONY LEATHER

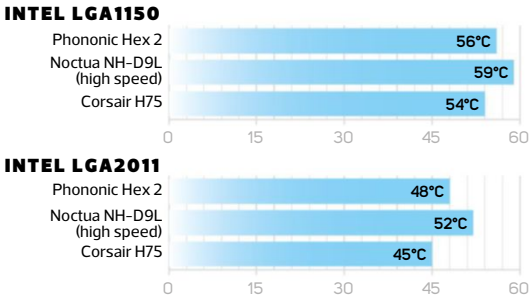
/SPECIFICATIONS

Compatibility Intel: LGA2011x, LGA115x; AMD: Socket AM3/3+, AM2/2+, FM2/2+, FM1

Heatsink Size (with fans) (mm) 112 x 95 x 125 (W x D x H)

Fans 1 x 92mm

Stated noise Up to 33dB(A)



LGA115x

COOLING	DESIGN	VALUE	OVERALL SCORE
33/40	27/30	19/30	79%

LGA2011

COOLING	DESIGN	VALUE	OVERALL SCORE
32/40	27/30	19/30	78%

VERDICT

Very expensive, but effective if you need great cooling in a tight space.

GRAPHICS CARD

Nvidia Titan X / £1,099 inc VAT

SUPPLIER www.nvidia.co.uk

Oh come on, Nvidia, £1,099? For one graphics card? That's just silly. If I was Graham Chapman, I'd be seriously thinking about marching over to your HQ in my uniform and giving you a stern talking to. Interestingly, you'll only be able to hand over 1,099 of your hard-earned pounds for a Titan X card at the Nvidia store as well, as it won't be available separately from retailers. The only way you'll be able to get your hands on one is via the Nvidia website, or via a prebuilt system such as the Scan 3XS X99 Carbon X SLI (see p64).

On the plus side, the specs are nearly as silly as the price. The Titan X is based on a new Pascal-based GPU core, called GP102 (the GTX 1080 uses the GP104 core), which has a 471mm^2 die filled with 12 billion 16nm transistors. Those transistors give you an awful lot of stream processors – 3,584, in fact – spread over 28 streaming multiprocessors (SMs) in six graphics processing clusters (GPCs), and the GPU has 96 ROPS at its disposal. The GPU has a base clock of 1417MHz, and an official boost clock of 1531MHz, although we regularly saw the GPU boost to over 1800MHz during our tests.

> We regularly saw the GPU boost to over 1800MHz during our tests

That boosting headroom is partly due to the efficiency of Nvidia's Pascal architecture, but also Nvidia's superb vapour-change reference cooler. It's very similar to the one on the GTX 1080 Founders Edition, but in this case, it gets noticeably hotter to the touch when the card is running at full pelt. However, it remains quiet.

Also on the PCB is a whopping 12GB of GDDR5X memory, although that's overkill for any current games, even at 4K with maximum settings and anti-aliasing. It's quick, though, running at the same 10GHz effective frequency as the GTX 1080. There are also two power connectors at the top – one 6-pin socket and one 8-pin socket, showing that the Titan X needs more juice than the GTX 1080 with its single 8-pin connector. Finally, you get three DisplayPort outputs on the backplate, along with an HDMI socket and a good old-fashioned dual-link DVI output.

/ SPECIFICATIONS

Graphics processor Nvidia Titan X, 1417MHz base clock, 1531MHz boost clock

Pipeline 3,584 stream processors, 96 ROPs

Memory 12GB GDDR5X, 10GHz effective

Bandwidth 480GB/sec

Compatibility DirectX 12, OpenGL 4.5

Outputs/inputs 3 x DisplayPort, 1 x HDMI, 1 x DVI-D-DL

Power connections 1 x 8-pin, 1 x 6-pin

Size 267mm long, dual-slot

Performance

The Holy Grail for high-end single-GPU cards for the past few years has been 4K gaming, and while Nvidia's Maxwell-based Titan X and GTX 980 Ti cards managed it with borderline-playable frame rates, the new Pascal-based Titan X nails it. Every one of our game tests wasn't just playable at 4K with maximum settings, but smoothly playable. It didn't even drop below 65fps in Doom at Ultra settings.

Even our usual Fallout 4, The Witcher 3 and Crysis 3 4K tests couldn't stop the Titan X, which never dropped below 49fps, 55fps and 44fps respectively. To step up the challenge, we enabled Ultra settings in Fallout 4, where the Titan X still remained playable at 33fps. We then upped the settings in The Witcher 3 to Ultra, with HairWorks enabled, and it still didn't drop below 39fps, and the game looks absolutely stunning at these settings.

At load, our test system drew 385W from the mains with the Titan X installed, slightly higher than with the Maxwell-based GTX 980 Ti installed, although the new Titan X is still more power-efficient than AMD's Radeon R9 Fury X. Interestingly, the Titan X's power consumption and clock speed went up and down a fair bit in our game tests, more than on the GTX 1080, suggesting the Titan X controls the clock speed quite aggressively. Also, in nearly all of our tests, the frame rate from the first run would be 2-3ps quicker than the other runs, pointing to the Titan X running flat out at first, but then holding itself back when it heats up. We ran each test four times, discarding the first result, to give a more accurate picture of performance.

Our Titan X sample had a surprising amount of overclocking headroom too. We were able to add another 250MHz to both the GPU core clock and the memory frequency, causing the Titan X's GPU clock to peak at a massive 2062MHz in games, while the memory ran at 5258MHz (10516MHz effective).

Conclusion

The Titan X may have a daft price tag, but it's the first single-GPU card that can properly handle 4K gaming at maximum settings without compromising. If that's what you've been waiting for, and you have buckets of cash at your disposal, then this card will do it.

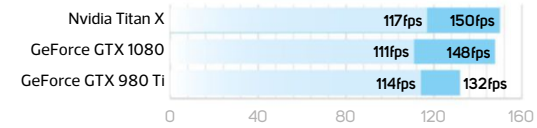
However, if Nvidia's previous launch strategies are any indication, a second, cheaper GPU based on the GP102 core, perhaps with one GPC disabled, may arrive in the near future. If you want the fastest gaming GPU right now, the Titan X is amazing, but we'd hold off and see what the future holds before spending such a large amount of money.

BEN HARDWIDGE

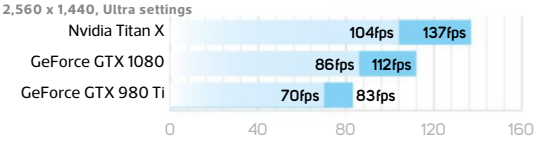
ELITE
NEW ENTRY
P66

DOOM

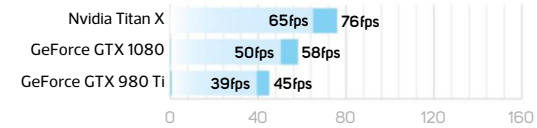
1,920 x 1,080, Ultra settings



2,560 x 1,440, Ultra settings

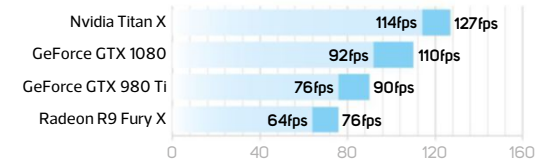


3,840 x 2,160, Ultra settings

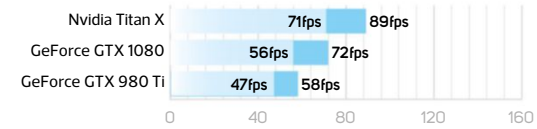


FALLOUT 4

1,920 x 1,080, Ultra detail, TAA

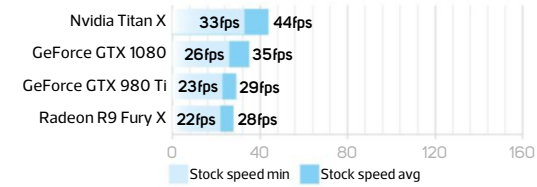


2,560 x 1,440, Ultra detail, TAA



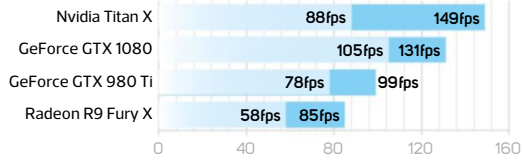
3,840 x 2,160, High detail, TAA

3,840 x 2,160, Ultra detail, TAA

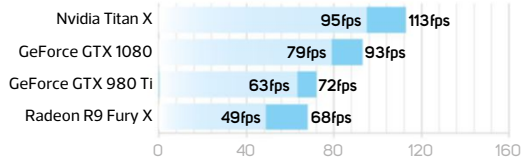


THE WITCHER 3: WILD HUNT

1,920 x 1,080, High detail, Nvidia HairWorks off

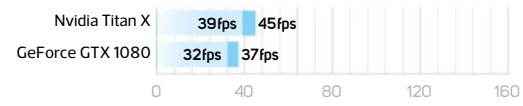


2,560 x 1,440, High detail, Nvidia HairWorks off



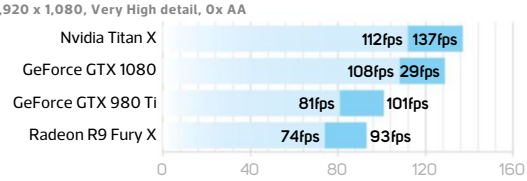
3,840 x 2,160, High detail, Nvidia HairWorks off

3,840 x 2,160, Ultra detail, Nvidia HairWorks on

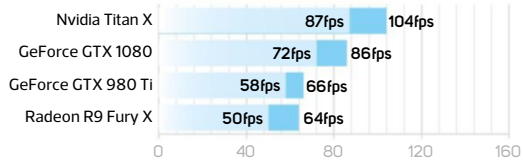


CRYSIS 3

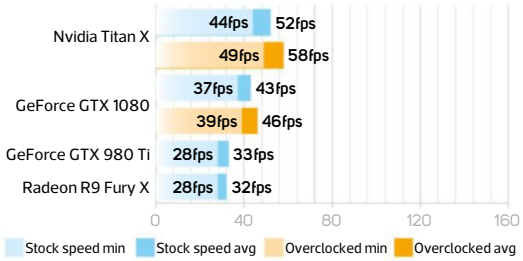
1,920 x 1,080, Very High detail, 0x AA



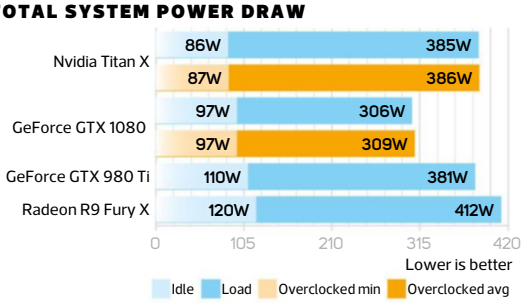
2,560 x 1,440, Very High detail, 0x AA



3,840 x 2,160, Very High detail, 0x AA



TOTAL SYSTEM POWER DRAW



SPEED 50/50

VALUE 12/40

EFFICIENCY 9/10

OVERALL SCORE 71%

VERDICT

The first single-GPU card that can properly handle 4K gaming, the Titan X is an amazing piece of engineering, but at this price, we'd hold fire for the moment.

GRAPHICS CARD

Asus Strix Gaming Radeon RX470 4GB / £187 inc VAT

SUPPLIER www.box.co.uk

Ah, that's more like it. It feels weirdly refreshing to see a graphics card costing £187 after the price shock of the Titan X (see p20). AMD is now filling out its Radeon RX 400-series line-up below the RX480, with the RX470 aiming to clear up in the very popular sub-£200 bracket. It's based on the same GPU as the RX480, but with four compute units (CUs) disabled, giving it 2,048 stream processors and 128 texture units, along with the same count of 32 ROPS found in the Radeon RX480.

At its stock specifications, the RX470 has a base clock of 926MHz and a boost clock of 1206MHz, although our Asus sample card was happy to run at its boost clock solidly throughout our game tests. As with other Asus graphics cards we've reviewed recently, the card is sent to reviewers with the OC mode enabled (with the boost clock at 1270MHz), while retail versions ship with the slightly lower-clocked Gaming mode enabled (with the boost clock at 1250MHz). We tested our sample in OC mode, at which the card was perfectly happy, with the cooler never getting too hot or loud. Comparatively, the RX480's stock boost GPU speed is 1266MHz, so this RX470 card is unlikely to be far behind it in terms of performance.

It laughs in the face of last-gen mid-range GPUs

Asus has approached the Strix RX470's cooler much more sensibly than its Strix RX480 and GTX 1060 cards too, which came with extravagant coolers that were arguably overkill for the mid-range GPUs used. The dual-fan DirectCU II cooler here, on the other hand, is ideal for a mid-range graphics GPU, keeping the price low while offering quiet and effective cooling. Asus has also updated the cooler into the LED world, with an LED on the top of the card, between the two fans, which can be controlled with the supplied Aura software.

Similarly sensible is the allocation of 4GB of GDDR5 memory on this graphics card. The main benefit of more memory is the ability to run games at higher resolutions and add more effects such as anti-aliasing, but 8GB of memory is wasted on cards that can only realistically play games at up to 2,560 x 1,440 – they'll never realistically use it all. The 4GB of memory here again helps to keep the price down, although its 6.6GHz (effective) speed makes it a fair bit slower than the RX480's 8GHz (effective) memory. On the plus side, the RX470 has the same 256-bit wide memory interface as the RX480, so there's no bottleneck on memory bandwidth going to the GPU.

Thanks to the lower clock speeds, cut-down GPU and smaller memory allocation, this RX470 card doesn't need too much power either, sporting just a single 6-pin PCI-E power connector. Finally, the backplate features a single DisplayPort 1.4 output, an HDMI 2b connector and a pair of dual-link DVI outputs. It covers most of your display bases, although it lacks the dual HDMI ports of Asus' more expensive cards, enabling you to connect the card to both a TV/monitor and a VR headset at the same time.

Performance

This Asus RX470 card laughs in the face of last-gen mid-range GPUs. In all our tests, it was significantly ahead of both the aging Nvidia GeForce GTX 960 and our previous favourite, the Radeon R9 380. It played all of our test games comfortably at 1,920 x 1,080, even staying above 60fps in Doom at Ultra settings.

Its frame rates stayed above 30fps at 2,560 x 1,440 in most of our test games too. It dropped down to 26fps in Fallout 4, which is still borderline playable but a little clunky. However, dropping this game's settings to High detail will make it smoothly playable. As we suspected, this Asus Strix RX470 card is only a small way behind the stock RX480 in these tests too, and it's similarly not far off the performance of stock-speed Nvidia GTX 1060 cards either.

Meanwhile, power consumption is respectably low, if not as outstanding as the performance per watt we've seen from Nvidia's recent Pascal cards. Our system drew just 255W with this Asus Strix RX470 card running at full pelt, which is significantly lower than the 291W it drew with the older Radeon R9 380 installed.

Conclusion

AMD Radeon RX480 cards have increased in price a fair bit since we first reviewed the stock model a couple of months ago, and it doesn't help that most of the cards available in the shops are 8GB versions, which needlessly bump up the price with memory you don't need. As such, this 4GB card hits the sweet spot, offering all the hardware you need to run games smoothly at 1080p with maximum settings, and

/ SPECIFICATIONS

Graphics processor AMD Radeon RX470, 1250MHz boost clock (Gaming mode), 1270MHz boost clock (OC mode)

Pipeline 2,048 stream processors, 32 ROPs

Memory 4GB GDDR5, 6.6GHz effective

Bandwidth 211GB/sec

Compatibility DirectX 12, OpenGL 4.5, Vulkan

Outputs/inputs 1 x DisplayPort 1.4, 1 x HDMI 2b, 2 x DVI-D DL

Power connections 1 x 6-pin

Size 242mm long, dual-slot

ELITE
NEW ENTRY
P66

it can even run most games at 2,560 x 1,440 with decent settings too, while still costing under £200.

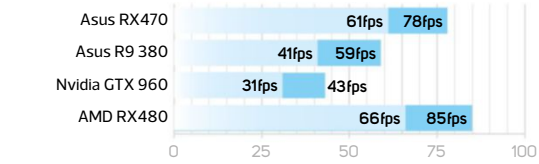
Unlike the stock AMD Radeon RX480, this Strix card has the benefit of Asus' excellent DirectCU II cooler, which is much quieter – and better-looking. The only potential obstacles in its path are the new GeForce GTX 1060 cards with 1,152 stream processors and 3GB of memory (see p14), which we haven't tested yet, but we expect them to perform similarly to Radeon RX470 cards.

Either way, the Asus Strix Gaming Radeon RX470 4GB is a great deal for £187 inc VAT, offering a quiet, attractive and well-built graphics card with a GPU that can happily handle the demands of 1080p gaming and more.

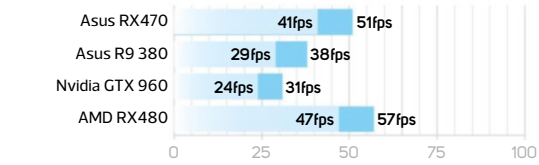
BEN HARDWIDGE

DOOM

1,920 x 1,080, Ultra settings

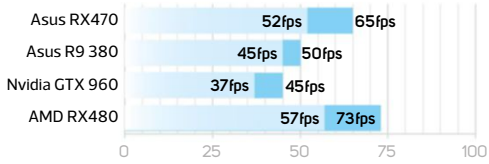


2,560 x 1,440, Ultra settings



THE WITCHER 3: WILD HUNT

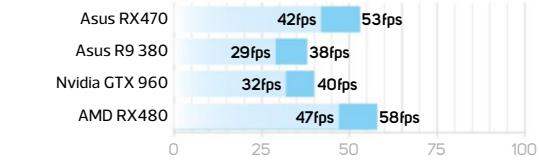
1,920 x 1,080, High detail, Nvidia HairWorks off



2,560 x 1,440, High detail, Nvidia HairWorks off

FALLOUT 4

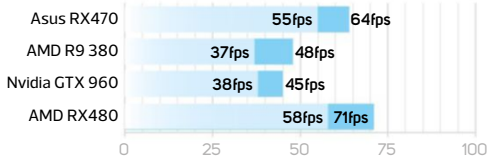
1,920 x 1,080, Ultra detail, TAA



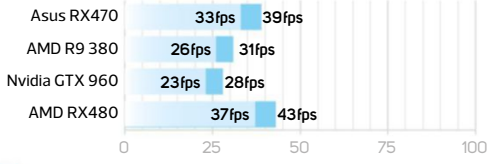
2,560 x 1,440, Ultra detail, TAA

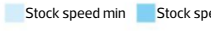
CRYSIS 3

1,920 x 1,080, Very High detail, 0x AA

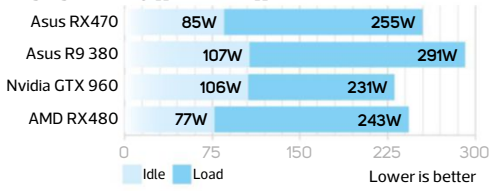


2,560 x 1,440, Very High detail, 0x AA





TOTAL SYSTEM POWER DRAW



STOCK AMD RADEON RX470

SPEED **39/50**

VALUE **36/40**

EFFICIENCY **9/10**

OVERALL SCORE **84%**

ASUS STRIX GAMING RADEON RX470 4GB

DESIGN & FEATURES **41/45**

PERFORMANCE **22/25**

VALUE **24/30**

OVERALL SCORE **87%**

VERDICT

All the hardware you need to play games smoothly at 1,920 x 1,080, and some games at 2,560 x 1,440, in a quiet, attractive, well built and affordable package.

ATX CASE

Be Quiet! Dark Base Pro 900 / £210 inc VAT

SUPPLIER www.scan.co.uk

We've seen a fair bit of innovation in the PC case market recently, both in terms of design and aesthetics. We've definitely moved on from the bland black box, but Be Quiet!'s Dark Base Pro 900 is looking to take the PC case to the next level with a reconfigurable interior.

Not only can the motherboard tray be swapped from one side of the case to the other, but it's flipped too, enabling you to use standard or inverted ATX layouts.

In addition, the motherboard tray can move up and down, allowing for more room in the base or additional clearance in the roof for thicker radiators. Blanking plates slot into gaps in the rear of the case when you raise the motherboard, so you don't leave any holes.

The tempered glass side panel and drive cage can swap sides

What's more, the tempered glass side panel and large drive cage can swap sides too, depending on where you mount the motherboard.

It's an unprecedented level of customisation, and it leads to equally great water-cooling support. A pump bracket is included, while both the roof and front sections can house either quad 120mm-fan or double 140mm-fan radiators. Dropping down the motherboard and removing the drive cage allows for full-height radiators to be mounted in both locations too.

Swapping hardware around is quite a complicated and time-consuming process, though, as all the parts are screwed in place and a lot of components use anti-vibration rubber pads too, which need to be realigned when you move the panels. Of course, you shouldn't need to move all your hardware around after your initial build – it's just that the initial build time will take longer than usual. That said, no amount of time will fix the cable routing. There's enough space behind the motherboard tray, with plenty of cable routing-holes and Be Quiet! even includes Velcro cable ties.

However, the PSU is exposed and the cables are clearly visible, which makes creating a neat system very difficult.

Reworking a PC case design to this degree also requires a fair bit of behind-the-scenes design work, which is partly why the Dark Base Pro 900 costs over £200. However, it also sports the aforementioned large tempered glass side panel, which looks fantastic, while the exterior is largely made from aluminium and the rest of the case is made from steel and plastic.

Also, while this modern-looking case lacks a forward-thinking USB 3.1 Type-C port, unlike some rivals, it also includes a feature we've never seen on a case before. There's a QI wireless charging pad embedded in the roof, which you can use to charge your compatible smartphone without any cables. It's a popular feature in a number of modern smartphones such as Samsung's Galaxy series and it would be great to see more cases offering this feature.

Meanwhile, the front panel includes an attractive power button, and a pair of USB 2 and USB 3 ports, plus audio jacks. The exterior is very good-looking in general, with black brushed aluminium stretching right around the case, while the front vents and drive bays are hidden by a swing-out door. Ventilation isn't amazing as a result, though, and is left to large mesh-covered vents in the sides of the case, plus elegant cut-outs in the aluminium at the rear.

A pair of 140mm SilentWings fans are included in the front of the case, with a third one in the rear fan mount and large removable dust filters in the front and base of the case too. Meanwhile, all of the seven removable 3.5in drive bays are located in the front of the case and each is compatible with two 2.5in SSDs as well, with a single dedicated 2.5in mount situated behind the motherboard tray. You also get a three-speed fan controller, an 8-channel PWM fan hub, an additional fan bracket that sits in the two 5.25in bays and two multi-coloured LED strips thrown into the bargain too.

Performance

In terms of air-cooling ability, the Dark Base Pro 900's CPU delta T of 56°C at maximum fan speed is rather average, with other large cases such as the SilverStone Primera PM01 and In Win 805 knocking several degrees off this result. The Dark Base Pro 900 was thankfully very quiet indeed, though, due to the lack of openings and the use of

/SPECIFICATIONS

Dimensions (mm) 243 x 577 x 585 (W x D x H)

Material Steel, plastic

Available colours Black/orange, silver/black

Weight 14kg

Front panel Power, reset, 2 x USB 3, 2 x USB 2, stereo, mic

Drive bays 2 x external 5.25in, 7 x 3.5in/14 x 2.5in, 1 x 2.5in

Form factor(s) E-ATX, ATX, micro-ATX

Cooling 3 x140mm or 4 x 120mm roof fan mounts (fans not included), 3 x 140mm/120mm front fan mounts (2 x 140mm fans included), 1 x 140mm/120mm rear fan mount (140mm fan included),

CPU cooler clearance 185mm

Maximum graphics card length 323mm (472mm without hard disk mounts)

HOW WE TEST
PAGE 38

1 The motherboard tray can be installed with a standard or inverted layout, and moved up and down

2 The QI wireless charging in the roof can charge compatible phones without cables

3 All of the seven removable drive bays can take one 3.5in hard drive or two 2.5in SSDs

SilentWings fans. Dropping the fan speed to minimum saw the temperature only rise to 61°C, which matched the In Win 909 with two fans installed.

The GPU delta T was similarly average at 56°C, although it rose just 1°C when we reduced the fan speed. Shifting the motherboard up and down had no impact on cooling, but interestingly, rotating the motherboard so the cooler was at the bottom of the case reduced the CPU delta T by 2°C, although this arrangement had little impact on the GPU temperature.

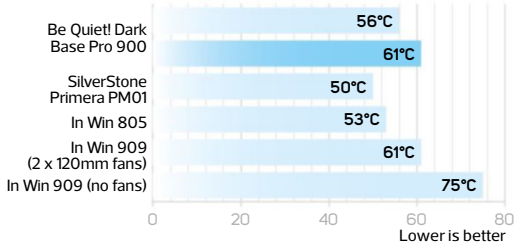
Conclusion

The Dark Base Pro 900 has a lot of competition in its price range with traditional, premium cases from the likes of In Win, Phanteks and SilverStone. It holds its own in the looks department, although some of In Win's offerings are better-looking. The Be Quiet! is superb for water cooling, though, and swapping hardware around does, in this case, have tangible benefits, so it's far from being a gimmick. Meanwhile, its air-cooling ability is good, if not exceptional, and there are plenty of options for water-cooing gear, although radiators might not perform as efficiently as possible with the lack of vents. Our other main criticism is the average cable-routing system.

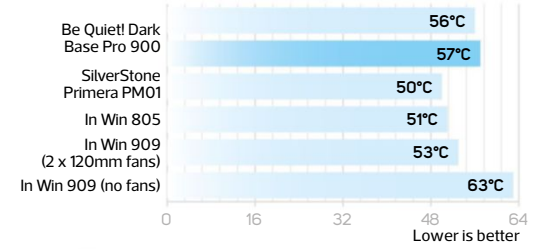
However, the whole package gives you a hugely flexible case and some unique features. The Dark Base Pro 900 isn't a must-have case, but if you have the money and want as much control over the interior as possible, it offers unrivalled flexibility and great looks.

ANTONY LEATHER

CPU LOAD DELTA T



GPU LOAD DELTA T



Max fan speed Min fan speed

COOLING 22/30

FEATURES 19/20

DESIGN 27/30

VALUE 15/20

OVERALL SCORE 83%

VERDICT

A great customisable case with modern features and good water-cooling credentials, although you pay a premium for them.

ATX CASE

Corsair Carbide Air 740 / £135 inc VAT

SUPPLIER www.scan.co.uk

While Be Quiet! has been tinkering with internal layout this month (see p24), Corsair has been hard at work refining and enlarging its unusual Carbide Air cases, which you may remember comprise its Air 240 and Air 540 cube cases. This time, its new Air Carbide Air 740 landed just in time for a review this issue, and it's a monster.

The case mirrors the dual-compartment internal layout of its predecessors, but with sizeable chambers for each section, so it has a hefty footprint. It measures 340mm wide – a good 100mm more than your average ATX tower, and its depth of over 510mm means you'll need some serious desk or floor real estate to house it, although it's still more compact than Corsair's Obsidian 900D. Corsair has made good use of that space, though, as the Air 740 is a fantastic case for housing all-in-one liquid coolers or custom water-cooling systems.

The adjustable fan mounts are begging to house large radiators

Externally, it isn't the prettiest case in the world, with ridges crisscrossing the front and top sections – it looks as though Corsair was simply trying to jazz up the grey plastic exterior a bit, but it still doesn't look particularly attractive. There's a large side window, though, and its panel swings out on a hinge for easy tool-free access.

Meanwhile, the front panel sports the usual ports and buttons, although there's sadly s no fan control here. Thankfully, the trio of included 140mm fans are very quiet, producing a low thrum and steady airflow through the case from front to back. The front, roof and base all have excellent ventilation too, with large mesh sections backed with removable dust filters.

Despite its size, only ATX boards are supported in this case – there's no E-ATX support. That isn't to say you couldn't build a monstrous system inside the Air 740, though, as the internal space on offer is substantial. All the external panels are removable, revealing a swathe of adjustable fan mounts that are begging to house large radiators. There's a good deal of clearance if you're thinking of air-cooling the case too, with 170mm of CPU cooler clearance and 370mm of space for graphics cards.

You can house a double 140mm fan radiator in the front, or up to a triple 120mm fan model, and there's essentially no height limit on the radiator here, with the motherboard and graphics card resting several inches away from the fans. You can house up to a double 140mm-radiator in the base and roof as well, with the option of fitting 60mm-thick radiators in both locations, depending on your motherboard and graphics card setup. It seems a shame, then, that there are no dedicated water-cooling hardware mounts – you'll need to find your own way of mounting a pump and reservoir.

Corsair's drive can be a little flimsy too, although it's good to have three 3.5in bays and four 2.5in tool-free mounts included. Interestingly, the 2.5in mounts can also be removed individually, stacking on top of one another in the rear section. However, we didn't find our SSD fitted particularly well, and ended up with a loose fit, despite having a standard size. Meanwhile, the PSU sits below this section and is secured in place by the usual rear screws, but as it placed on its side, there's an adjustable plate included, which meets the PSU to provide some extra lateral support.

As you'd expect from Corsair, there's ample cable-routing options – perhaps even too many given the lack of reservoir mounts that could also have been situated in this case. Build quality is reasonable too, with a steel and plastic construction, although the far side panel and some aspects of the interior feel a little tinny, at least for a case costing upwards of £130.

Performance

We suspected the Air 740's cooling would be fairly potent with the large areas of mesh and three 140mm fans, and we weren't wrong – the case's CPU delta T of 49°C betters the results from SilverStone's Primera PM01 and In Win's 805, and also knocks a few degrees off the temperatures we saw from Corsair's Carbide 600C. It was a similar situation with the GPU delta T; the result of 46°C easily beat most of the cases we've tested recently.

While the fans are relatively inconspicuous, especially under the din of an air-cooled graphics card and CPU, the

/SPECIFICATIONS

Dimensions (mm) 340 x 510 x 426 (W x D x H)

Material Steel, plastic

Available colours Black

Front panel Power, reset, 2 x USB 3, stereo, mic

Drive bays 3 x 3.5in/ 2.5in, 4 x 2.5in

Form factor(s) ATX, micro-ATX

Cooling 2 x120/140mm roof fan mounts (fans not included), 2 x 140mm/3 x 120mm front fan mounts (2 x 140mm fans included), 1 x 120/140mm rear fan mount (140mm fan included),

CPU cooler clearance 170

Maximum graphics card length 370mm

1 You can house a double 140mm fan radiator in the front, or up to a triple 120mm fan model

2 There are loads of cable-routing holes by the motherboard, but no pump mount

3 With no drive bays here, you get a massive 370mm of graphics card clearance

extensive mesh did allow a fair amount of noise to escape the case. However, the Air 740 is clearly geared towards liquid cooling, and the ability to use several large radiators means you could use slow-spinning fans, yet still get great cooling without allowing too much noise to spill into the room.

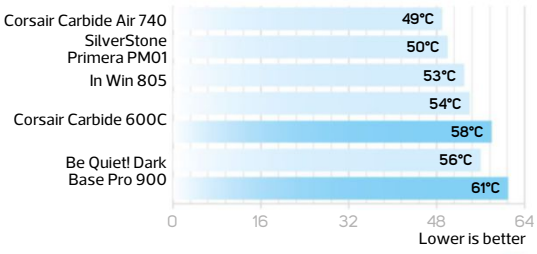
Conclusion

If you want a case with loads of room for water-cooling gear, or to get as much airflow as possible, then Corsair's Air 740 is undoubtedly deserving of your shortlist. It packs nearly as much radiator support as Corsair's huge and much more expensive Obsidian 900D in a much more compact chassis. That isn't to say the Air 740 is small though – it's a big case with a sizeable footprint, but it offers excellent support for water-cooling gear, and the airflow performance is fantastic.

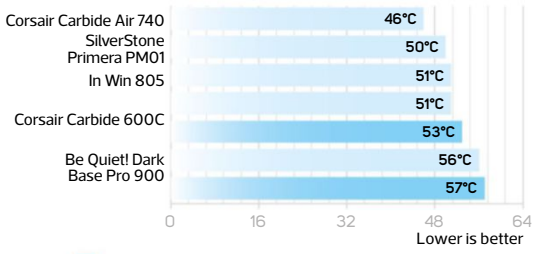
There are some niggles, though, such as the slightly flimsy construction in some areas, the lack of dedicated mounts for water-cooling gear (especially given the case's focus) and the lack of fan control. It's not great-looking either. If its price was closer to £100, it might have been in line for an award, but with better-looking cases such as In Win's 805 retailing for the same price, and the likes of NZXT's H440 and SilverStone's PM01 costing £40 less, it's up against some stuff competition. However, the Carbide Air 740's unique design and roomy interior enable it to carve out a niche that still makes it worth buying if large-scale water cooling or serious air cooling are your priorities.

ANTONY LEATHER

CPU LOAD DELTA T



GPU LOAD DELTA T



Max fan speed Min fan speed

COOLING	FEATURES
28/30	15/20
DESIGN	**VALUE**
24/30	15/20

OVERALL SCORE 82%

VERDICT

Excellent airflow and a huge amount of space for water-cooling radiators, although it's expensive and has a few design niggles.

PC Specialist recommends Windows Windows 10

Performance without compromise

Spectre Lite

- AMD FX-4300
- ASUS® M5A97 R2.0
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 950
- 1TB Hard Drive
- Corsair 350W PSU
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £499*

Gladius 900

- Intel® Core™ i5-6600K
- ASUS® Maximus VIII Hero
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 960
- 1TB Hard Drive
- Corsair 450W PSU
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £899*

Vitrum

- Intel® Core™ i5-6600K
- ASUS® Z170-E
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 970
- 400GB Intel® 750 PCIe SSD
- 1TB Hard Drive
- **Windows 10**
- 3 Years Warranty

THIS SPEC FROM £1,199*

Glacier

- OC Intel® Core™ i7-6700K
- ASUS® Maximus VIII Hero
- 16GB Corsair Vengeance RAM
- 6GB NVIDIA® GeForce™ GTX980Ti
- 400GB Intel® 750 PCIe SSD
- 2TB Hard Drive
- **Windows 10**
- 3 Years Warranty

THIS SPEC FROM £1,799*

14" Enigma VI

- Intel® Core™ M CPUs
- Intel Integrate Graphics
- Ultra thin: Just 15.6mm!
- Full HD IPS Screen
- Up to 7.5 Hours Battery
- Wireless as standard
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £409*

15.6" Octane II

- 6th Gen Intel® Core™ CPUs
- NVIDIA® GeForce™ Graphics
- NVIDIA® G-SYNC™ Option
- Full HD IPS Screen
- Thunderbolt™ 3
- Wireless as standard
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM £1,119*

Order your system now with PC Specialist

/pcspecialist @pcspecialist

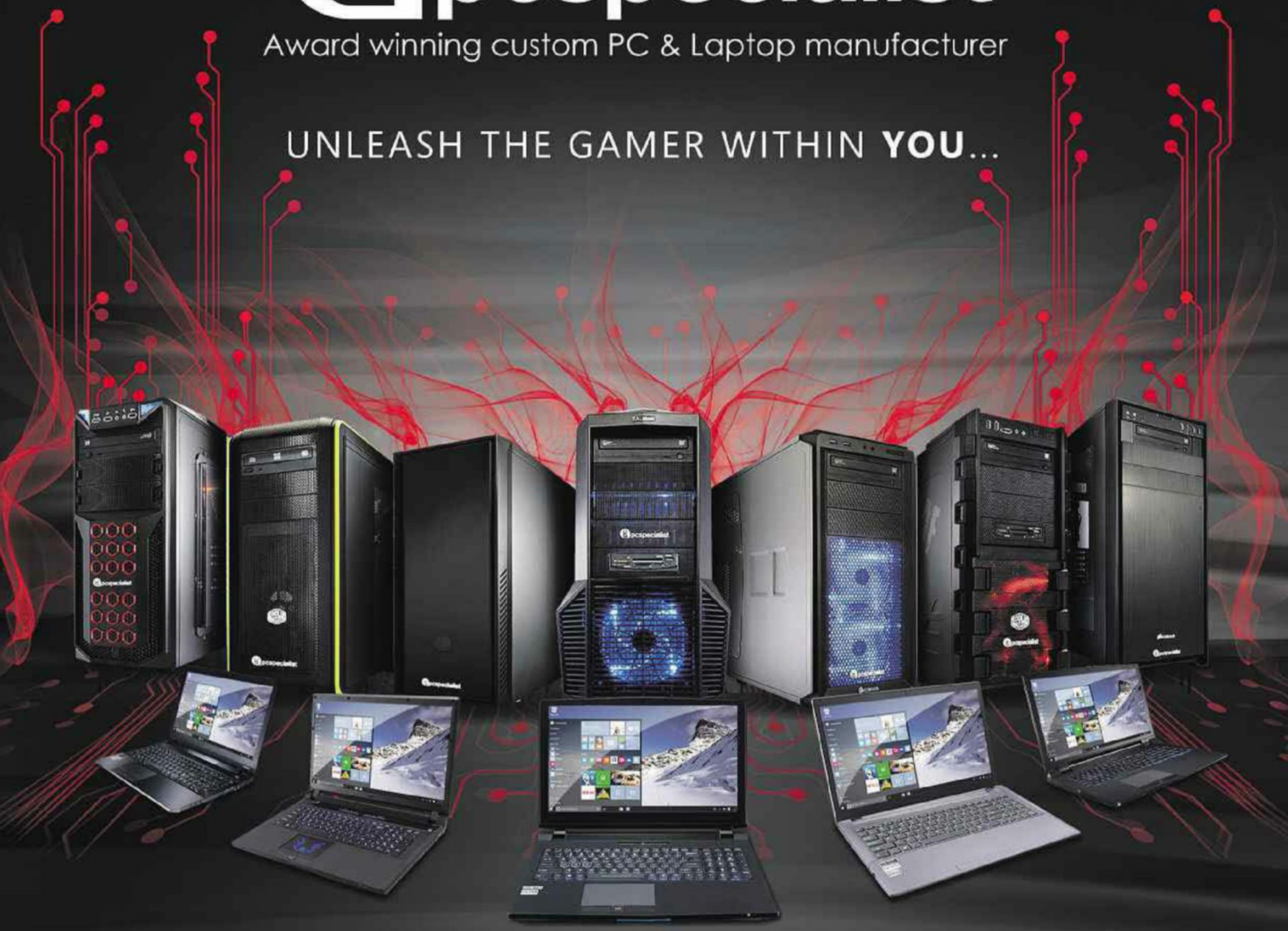
Some features require Windows 8.1. Update available through Windows Store. Internet access required; fees may apply.
Microsoft, and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

* Prices are including VAT and are correct at the time of printing, but subject to change.

pcspecialist

Award winning custom PC & Laptop manufacturer

UNLEASH THE GAMER WITHIN **YOU**...



Vulcan 440

- Overclocked Intel® Core™ i7-4790K
- ASUS® Maximus VII Ranger
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 980
- 500GB Samsung EVO 850 SSD
- 2TB Hard Drive
- **Windows 10**
- 3 Year Standard Warranty

THIS SPEC FROM **£1,499***

Quality builds at a low price
Always

GET A FURTHER £15 OFF WITH THIS EXCLUSIVE VOUCHER CODE:

CPC15

ORDER ONLINE NOW

0333 011 7000

www.pcspecialist.co.uk

ATX MOTHERBOARD

MSI Z170A MPOWER Gaming Titanium / £210 inc VAT

SUPPLIER www.scan.co.uk

We're now a whole year on from Skylake's launch and enthusiasts are already getting excited about Intel's next CPU core – Kaby Lake. Before then, though, we're still seeing a trickle of refreshed Z170 boards with new features. As well as offering some aesthetic boosts, these new boards such as MSI's Z170A MPOWER Gaming Titanium, also sport useful physical features too.

It's mainly about the aesthetics with MSI's latest Z170 board, though, with it sporting the same metallic, grey/granite finish as other boards in the Titanium range, hence the name. It looks fantastic, and it's a far cry from the black models we've seen recently from both MSI and Asus, which usually rely on RGB lighting to jazz up their appearance.

There's no customisable lighting here – the Z170A MPOWER Gaming Titanium relies solely on its paint scheme to score points, although it does include a 4-pin RGB LED header plus extension cables to control third-party LEDs, plus the DIMM slots and 16x PCI-E slots feature steel covers. The Titanium finish also extends to a large shroud that covers the audio circuitry and unsightly I/O ports, while also topping the PCH and VRM heatsinks. Whatever your colour scheme, the Z170A MPOWER Gaming Titanium's neutral aesthetics should work well with it.

The EFI's GUI is well laid out with snappy, lag-free response

That's just as well because, at £210, it certainly isn't cheap. One of our favourite boards – Asus' Maximus VIII Ranger – retails for £30 less, and the MSI board lacks Wi-Fi and most on-board overclocking and testing tools as well. Thankfully, it has some extra features to help justify the extra cash. It has two M.2 ports, potentially enabling you to install two NVMe PCI-E SSDs in a RAID array. It also includes a U.2 port, which is the other form of next-gen storage, although U.2 choices are less varied and more expensive than their M.2 counterparts. Using both M.2 ports or the U.2 port will see the total number of usable SATA 6Gbps ports reduced, as they share bandwidth – you'll need to step up to an X99 system to really kit your system out with next-gen storage.

Meanwhile, if you're considering a CrossFire or SLI setup with two GPUs, you'll be pleased to hear that the first and second 16x PCI-E slots are double-spaced with a 1x PCI-E slot sandwiched in between them, which should allow large air-cooled graphics cards to breath. As you'd expect, there are both USB 3.1 Gen 2 Type-A and Type-C ports as well, and MSI has also seen fit to include a Type-C port next to the SATA ports too, catering for new cases that include them on their front panels.

/SPECIFICATIONS

Chipset Intel Z170
CPU socket Intel LGA1151
Memory support 4 slots: max 64GB DDR4 (up to 3866MHz)
Expansion slots Three 16x PCI-E 3, three 1x PCI-E 3
Sound Realtek ALC1150
Networking Intel I219-V Gigabit LAN
Overclocking Base clock 98–341MHz, CPU multiplier 8–80x; max voltages, CPU 1.55V, RAM 2.2V
Ports 1 x U.2 32Gbps, 2 x M.2 4x PCI-E 3 32Gbps/SATA 6Gbps, 6 x SATA 6Gbps, 1 x USB 3.1 Type-C, 1 x USB 3.1 Type-A, 1 x USB 3 Type-C, 6 x USB 3 (four via header), 6 x USB 2 (two via header), 1 x LAN, audio out, line in, mic, Optical S/PDIF out, HDMI 1.4, DVI-D
Dimensions (mm) 305 x 244

Performance

We're consistently impressed by MSI's EFI, and the Z170A MPOWER Gaming Titanium saw much of the same. The GUI is well laid out with snappy, lag-free response, and all the essential settings are easy to find, including a decent cooling control section for tuning fan profiles. The EFI made it easy to overclock our Core i7-6700K, although we only managed to get our test CPU to 4.7GHz – not our usual 4.8GHz – despite pumping more than 1.4V through the CPU.

We also spotted that, during stock speed tests, the Turbo frequency would ramp up to 4.2GHz quite regularly, which resulted in some very competitive results in our benchmarks, where only the more expensive MSI Z170A XPOWER Gaming Titanium Edition and Asus Maximus VIII Formula managed to outperform it, and only by slim margins. Once overclocked, the 100MHz deficit was clear, though, with the system score of 146,164 being several thousand points short of the next slowest result.

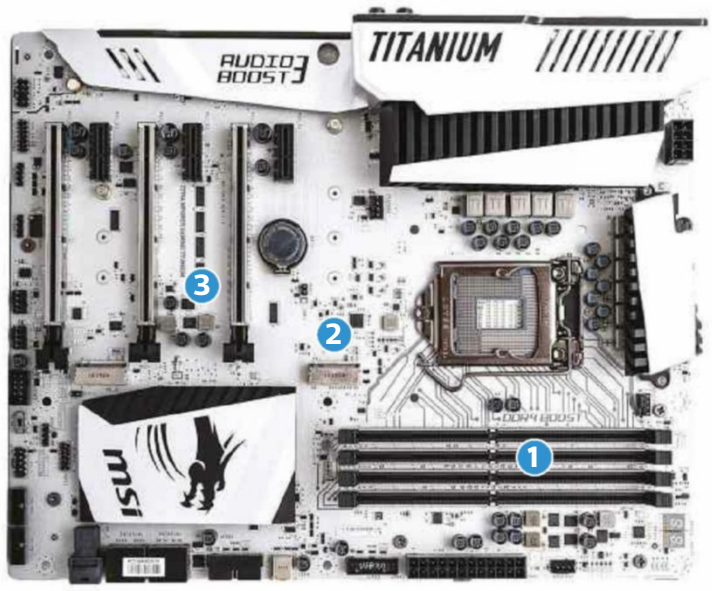
However, we wouldn't recommend using your CPU 24/7 at these levels anyway, so only extreme overclocking will be affected here. As our game test showed, this deficit is likely to have zero impact on gaming frame rates too.

Meanwhile, audio performance was standard for Realtek ALC1150 on-board sound, with noise and dynamic range levels of -103.4dBA and 103.3dBA respectively at 24bit/192KHz, which is better than many sub-£40 sound cards. There were no issues with storage performance either, with the Z170A MPOWER Gaming Titanium hitting near-maximum throughput on its M.2 ports, with read and write speeds of 2,282MB/sec and 958MB/sec respectively.

1 **The DDR4 DIMM slots and 16x PCI-E slots feature steel covers**

2 **There are two M.2 sockets, with one sensibly located above the slots**

3 **The first and second 16x PCI-E slots are double-spaced for dual-slot cards**



Conclusion

There are some caveats with the Z170A MPOWER Gaming Titanium, namely its lack of features such as Wi-Fi, as well as power and reset buttons, and a clear-CMOS switch. We'd expect most of these features to be included on a Z170 board costing over £200.

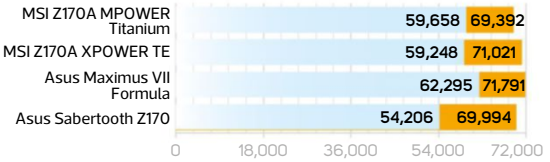
However, the Z170A MPOWER Gaming Titanium's goal isn't to offer an endless list of features, but a unique design. It looks spectacular, and it would look even better when coupled with some white LEDs, especially if it's sitting inside a clean, white case.

The rest of the specification is solid, although we question the use of U.2 on Z170, given the cost of the SSDs. It's great to see two M.2 ports too, allowing potential for security from a RAID 1 array, or increased performance (and higher risk) from a RAID 0 setup. While the Z170A MPOWER Gaming Titanium isn't dripping with features, it still comes highly recommended if you're after a high-performing, good-looking motherboard.

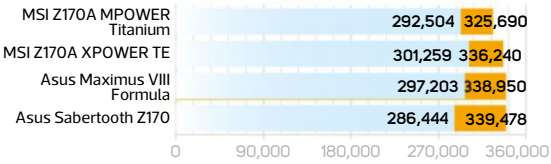
ANTONY LEATHER

CPC REALBENCH 2015

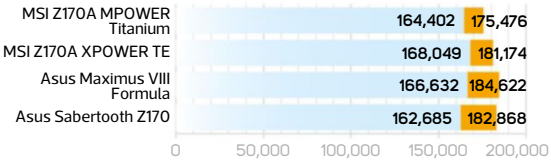
GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING

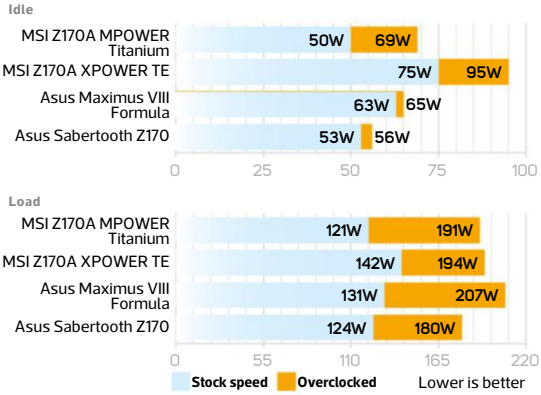


HEAVY MULTI-TASKING



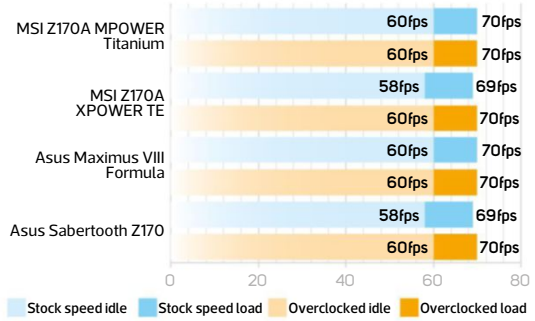
SYSTEM SCORE

TOTAL SYSTEM POWER CONSUMPTION



TOTAL WAR: ATTILA

1,920 x 1,080, 0xAA, Quality setting



PERFORMANCE 25/30 | **FEATURES** 32/35

VALUE 28/35

OVERALL SCORE 85%

VERDICT

A great-looking, high-performance motherboard with a decent EFI, though the lack of Wi-Fi and on-board overclocking features means it's a little overpriced.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc 100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

GAMING LAPTOP

XMG P507 / £1,951 inc VAT

SUPPLIER www.mysn.co.uk

The XMG P507's understated appearance hides one of the world's greatest mobile GPUs: the Nvidia GeForce GTX 1070. The new GPU core uses Nvidia's Pascal architecture used to full effect, with only minor changes to the core create the mobile variant (see below). There's plenty to like about the rest of the specification too. The Core i7-6700HQ has four physical cores, plus four virtual cores via Hyper-Threading, and its 3.5GHz Turbo pace is quick too.

It's accompanied by 16GB of 2400MHz memory, while Windows 10 is installed on a 256GB Samsung NVMe SSD and there's a 1TB hard disk too. Other specifications are also available if this P507 is too pricey. Dropping down to the GTX 1060 lowers the price to £1,609 inc VAT, and the entry-level model has 8GB of memory, a 500GB hard disk and no operating system for £1,299 inc VAT.

The GTX 1070 offered silky frame rates at the native 1080p resolution

The 15.6in screen also supports G-Sync, which eliminates tearing and juddering by matching the screen's refresh rate to the GPU frame rate, up to a limit of 75Hz. Less endearing is the 1080p resolution though – it means you don't have to engage Windows 10's scaling options, but it feels meagre with the GTX 1070 on board.

The components sit inside a dark aluminium chassis from Taiwanese laptop maker Clevo. The lid is only decorated with a dark XMG logo, there's a tiny XMG logo above the keyboard and the keyboard has a white backlight, but that's it for decoration – the P507 looks more like a smart business laptop than a barnstorming gaming machine. The entire machine also weighs 2.94kg with a 32mm thickness – entirely ordinary dimensions, although you can't expect a tiny thin and light machine with this spec. The wrist rest also flexes a little when pushed and the slim lid bends too easily.

On the plus side, the interior is impressively accessible. The memory and storage can all be removed easily, and the cooling gear is numbered to simplify removal. There's also one spare 2.5in bay and two vacant M.2 sockets, while the packed exterior offers USB 3.1 Type-C ports, mini-DisplayPort outputs and both SD and SIM card slots.

There are no surprises in the keyboard's layout – we're always pleased to see a separate numeric keypad, and the spacebar and return keys are amply sized.

Begin typing, though, and you'll find that the keys are a tad too wobbly, and the base is soft, so the keys lack a speedy, snappy action. The keys only offer middling travel, and the WASD buttons aren't reinforced either, despite their highlighted surfaces.

Scrabble-tile keyboards are rarely as good as a full mechanical unit, of course, but other laptop keyboards still beat the XMG thanks to firmer, snappier and more consistent typing. The keyboard isn't awful, but it could be better. The touchpad suffers similarly; its discrete buttons feel soft and slow compared with USB mice, and the surface has too much friction for frantic gameplay – you'll want to use a proper mouse for gaming.

The pad sits on the left, which also means it's possible to brush the surface while using the WASD keys – an irritating bit of design. On the plus side, the two speakers produce crisp, nuanced high-end sounds and punchy treble, although there isn't much bass.

Performance

The GTX 1070 didn't balk at our game tests, offering silky-smooth frame rates at the P507's native 1080p resolution. Its slowest minimum came in Crysis 3, where it hit 54fps,

/SPECIFICATIONS

CPU 2.6GHz Intel Core i7-6700HQ

Memory 16GB 2400MHz DDR4

Graphics Nvidia GeForce GTX 1070 8GB (mobile)

Screen size 15.6in 1,920 x 1,080 Nvidia G-Sync IPS

Hard disk 256GB Samsung SM951 NVMe M.2 SSD, 1TB hard disk

Weight 2.94kg

Networking Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Ports 3 x USB 3, 2 x USB 3.1 Type-C, Gigabit Ethernet, 3 x audio, SD card slot, HDMI, 2 x mini-DisplayPort, SIM card slot

Dimensions (mm) 385 x 270 x 32 (W x D x H)

Operating system Windows 10 Pro 64-bit

Warranty One year parts and labour return to base

NVIDIA GEFORCE GTX 1070 (MOBILE)

Nvidia has only made minor changes to the desktop GTX 1070 to create its mobile version: the stream processor count has increased from 1,920 to 2,048, but the clock speed has dropped from 1683MHz to 1645MHz. Confusingly, the new mobile GTX 1070 actually replaces the GTX 980M, while the new mobile GTX 1080 replaces the mobile GTX 980 and the mobile GTX 1060 supersedes the GTX 970M.

The mobile GTX 1070's specs leaves the P507's 1080p screen feeling like a missed opportunity, though, so we ran tests at higher resolutions to find this GPU's limits. Not surprisingly, the mobile GTX 1070 blitzed our tests at 2,560 x 1,440, only dropping to 39fps in Crysis 3 at 39fps, while managing a solid 45fps minimum in Fallout 4 and a fantastic 59fps in The Witcher 3. The new card can't quite handle 4K without reduction graphical quality though. It could only manage 21fps minimums in Crysis 3 and Fallout 4, although it hit 38fps in The Witcher 3.

HOW WE TEST
PAGE 38

and it neared 70fps in Fallout 4. The GTX 1070 clearly has potential beyond 1080p.

The P507's IPS screen is solid elsewhere though. Its brightness level of 320cd/m² is high, and its black level of 0.32cd/m² is good – those figures combine for 1,000:1 contrast, which is ample for rendering inky blacks and vivid colours. Colour accuracy is decent too. The average delta E of 3.31 is fine, and the gamma measurement of 2.31 isn't far from the 2.2 ideal. The colour temperature of 7,019K is cool, but not enough to prove distracting. There's also only around 10 per cent in brightness variation across the panel, which is good for a laptop – and no sign of backlight bleed either. The P507's screen is decent in every department, and G-Sync support is great too.

Likewise, the processor's overall system score of 102,061 shows it has enough power to avoid gaming bottlenecks and easily handle home applications, while the SSD's sequential reads and write speeds of 1,937MB/sec and 1,226MB/sec are excellent.

The P507 only faltered in thermal tests. The CPU and GPU delta Ts of 68°C and 58°C are comparatively high, and heat escaped the case in numerous ways. A vent on the left-hand side pumped out hot air, which isn't ideal for left-handers using USB mice.

The top-left area of the keyboard also became toasty, and the back of the base panel was hotter – fine if you're at a table, but not so good if the P507 is on your knees. At least the consistently low fan noise was modest.

Battery tests provided no surprises either. While gaming, the XMG lasted for around 90 minutes, which isn't bad, but it's likely that any benefits from the Pascal architectures efficiency are wiped out by the relatively small 60Wh battery.

Conclusion

The P507 puts all its stock into the GTX 1070, breezing through 1080p gaming tests and even offering enough headroom for higher resolutions and VR headsets. The rest of the specification is fine, if not surprising – good CPU power, fast storage and ample memory sit alongside a decent screen. However, the keyboard and touchpad are mediocre, and the exterior lacks the pizzazz of most rivals. Still, the P507 remains a good option if you prioritise performance, and it's well priced for the speed on offer.

MIKE JENNINGS

CPC REALBENCH 2015

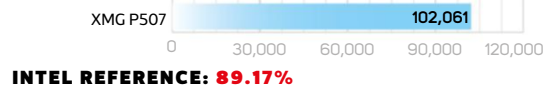
GIMP IMAGE EDITING

HANDBRAKE H.264 VIDEO ENCODING

LUXMARK OPENCL

HEAVY MULTITASKING

SYSTEM SCORE

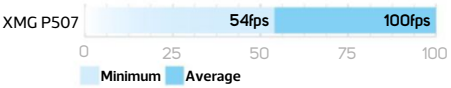


INTEL REFERENCE: 89.17%

FALLOUT 4
1,920 x 1,080, Ultra Detail, TAA

WITCHER 3
1,920 x 1,080, High Detail, AA on

CRYSIS 3
1,920 x 1,080, Very High Detail, 0x AA



SPEED	DESIGN	OVERALL SCORE
24/25	17/25	81%
HARDWARE	**VALUE**	
19/25	21/25	

VERDICT

Enviable graphics power, a decent screen and fast storage for a fair price, but it could do with a better keyboard and touchpad.

Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

BLUETOOTH SPEAKER

Harman Kardon Go + Play / £250 inc VAT

Harman Kardon is potentially being a little optimistic emphasising the portability of the Go + Play. Yes, the speaker is movable; it has a handle and an eight-hour battery life to keep it going on the road, but if you were to pack it for a holiday, you might have to leave behind all your clothes to make room for it.

The speaker's bulk costs it portability points, but it means there's plenty of room for two 3.5in drivers, a pair of 1in tweeters and a large central passive bass radiator. The effect is a very even, round sound that's more than capable of filling a large room or garden. For this price, though, we're surprised that neither aptX nor Spotify Connect are supported – an omission that makes the Go + Play feel a little technically behind the times.

●●●●○

SUPPLIER www.harmankardon.co.uk

BLUETOOTH SPEAKER

Libratone One Click / £139 inc VAT

Bluetooth speakers come in all shapes and sizes these days. Take the One Click, for example, which is the shape, size and weight of a hardback book. The benefit of this shape (according to Libratone) is that it provides a 360-degree arc of sound, as the One Click has speakers on both large flat sides. This system works, if you can stand it up on one of its narrow ends, but we found many instances where we couldn't stand it up. It was unsteady on the uneven ground of a park, for example, and on a gently rocking boat.

The sound from the speaker is good, however. It's full and rich with a deft balance between high, mid and low frequencies, meaning that the speaker suits most audio. It's just silly that it will only pump out half its audio output in places where you can't stand it up.

●●●○○

SUPPLIER www.libratone.com

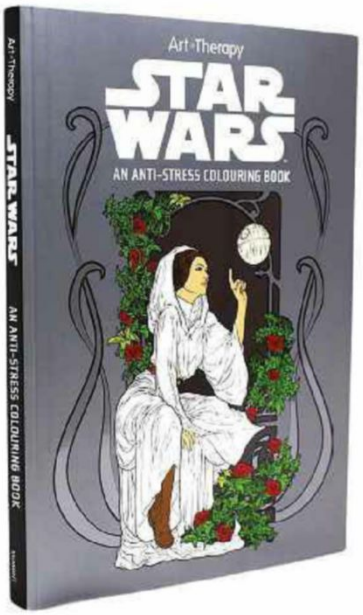
COLOURING BOOK

Star Wars Art Therapy Colouring Book / £8 inc VAT

Adding further evidence to our suspicion that, eventually, someone will stick Star Wars branding on absolutely everything, here is the Star Wars Art Therapy Colouring Book.

Unlike average colouring books, art therapy books are targeted at adults, aiming to help them relax and relieve stress.

We can't say for sure if the couple of pages we completed made a tangible difference to our stress levels, but it was a satisfying experience. The artworks are inspired by the first six films, and are custom made in the intricate, mandala-inspired style from which most art therapy books draw, making £8 inc VAT feel like good value for money. Expect big, double-page spreads of tessellated stormtrooper heads and swirling patterns of lightsabers.



●●●●○

SUPPLIER www.whsmith.co.uk

ROBOT TOY

Sphero SPRK+ / £100 inc VAT

The SPRK+ marks a change in tack for Sphero, as it's billed more as an entertaining way for kids to learn code, rather than an out-and-out toy. Playing to this billing, the outer shell is transparent, exposing the internal circuitboards, servos and motors, and it's great to see it all in action. The ball is coded via the Lightning Lab app, which offers a clearly laid out and intuitive way for children to get acquainted with coding operators such as 'equals' and 'less than'. It's fun too – programming routes and seeing the robot enact them is rewarding, and we could completely see class competitions for achieving the fastest maze completion and so on. Battery life is a sticking point, as you still only get an hour of action, but the SPRK+ has more going for it than previous Sphero robots.

●●●●○

SUPPLIER www.apple.com

MOUSE PAD

Sandberg Gel Mousepad Wrist + Arm Rest / £38 inc

If you use a keyboard and mouse for long periods of time, you'll want your wrists to sit as comfortably as possible. A wrist rest can certainly offer more comfort, but Sandberg has gone one step further with this set, which features an arm rest too. The effect is quite glorious, as if you have a plush, squidgy bed for your arm.

Unfortunately, though, it can be awkward to use. As it's designed to accommodate your whole forearm, you need to make room on your desk to rest every bit of your arm from your elbow downwards. We couldn't find a comfortable position to do so, no matter how many arrangements we tried, as it always left us leaning forwards over our desk uneasily. It works better on a wraparound desk, but everyone else will be better off with a standard wrist rest.

●●●○○

SUPPLIER www.amazon.co.uk

HAIRDRYER

Dyson Supersonic / £300 inc VAT

Beauty products are hardly a **Custom PC** staple, but how could we resist the engineering that must have gone into a £300 hairdryer that looks nothing like a hairdryer? The odd aesthetics are made possible thanks to Dyson's V9 Digital Motor, which is so small that Dyson has been able to locate it in the dryer handle. This setup allows the head to be a ring-shaped, meaning that it can use the same Air Multiplier principles used by the company's fans.

To put it to the test, I called in my better half with long hair, who reported that the effect is quite excellent. It's noticeably quieter than normal dryers, despite drying hair quicker, and the accessories attach with magnets rather than fiddly clips, which is a slick touch.

The quirky design and decent features can't quite excuse the stratospheric price, of course, but it's a great, swanky hairdryer if you have the money.

●●●●○

SUPPLIER www.dyson.co.uk

Seen something worthy of appearing in Custom Kit? Send your suggestions to editor@custompcmag.org.uk

SUBSCRIBE NOW!

Subscribe to CUSTOM PC today and save on the single issue price.

Each issue of ***Custom PC*** will be delivered directly to your device each month.

SEE NEXT PAGE FOR SET-UP INSTRUCTIONS

HOW TO SUBSCRIBE...

...on an iPad or iPhone

STEP 1 Return to the ***Custom PC*** library

STEP 2 Choose your subscription term and tap twice on the 'price' box

STEP 3 Choose whether to create an optional PixelMags account

STEP 4 Enter your Apple ID password to confirm

Download on the App Store

...on a Kindle Fire

Kindle Fire subscriptions come with a FREE one month trial.

STEP 1 Tap 'Free Trial Subscription' in the ***Custom PC*** library

STEP 2 Chose your subscription term from the drop down menu on the popup that appears

STEP 3 Tap 'Subscribe'

available on kindle fire

...on an Android device

STEP 1 Open the Google Play Store homepage and navigate to the Newsstand section using the tabs at the top

STEP 2 Search for ***Custom PC*** using the search icon in the top right of the screen

STEP 3 Click the 'Subscribe' button and pick your term

STEP 4 Enter your Google password to confirm

android

...via the [redacted] app

STEP 1 Search for ***Custom PC*** via the search box in the Shop tab

STEP 2 Tap the 'Subscribe' button

STEP 3 Choose whether to create an optional [redacted] account

STEP 4 Enter your Apple ID password to confirm

Subscribe to *Custom PC* today and save on the single issue price

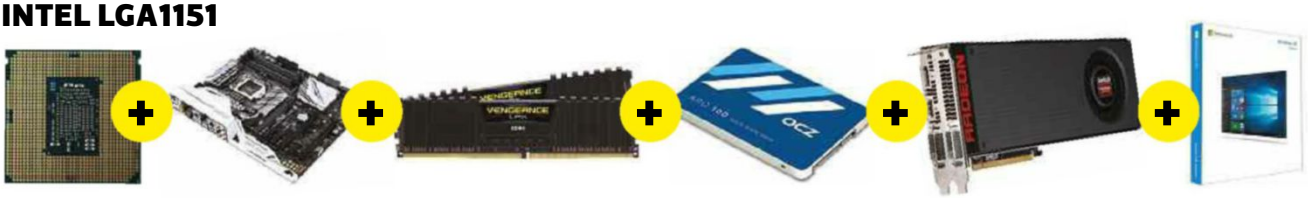
How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

PROCESSORS

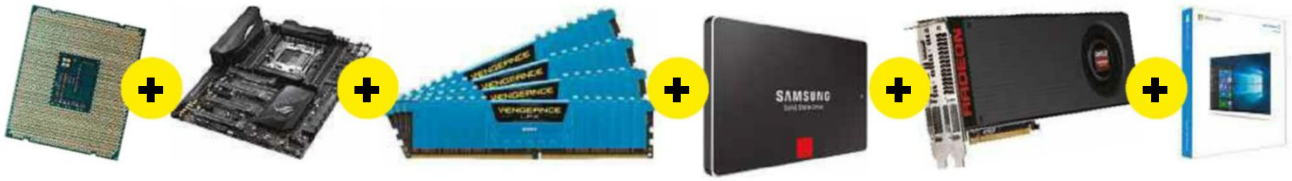
We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1151



Intel LGA1151 CPU | Asus Z170 Deluxe (ASRock Z170 Extreme4 for Core i3 6100 test) | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100 | AMD Radeon R9 390X | Windows 10 64-bit

INTEL LGA2011-V3

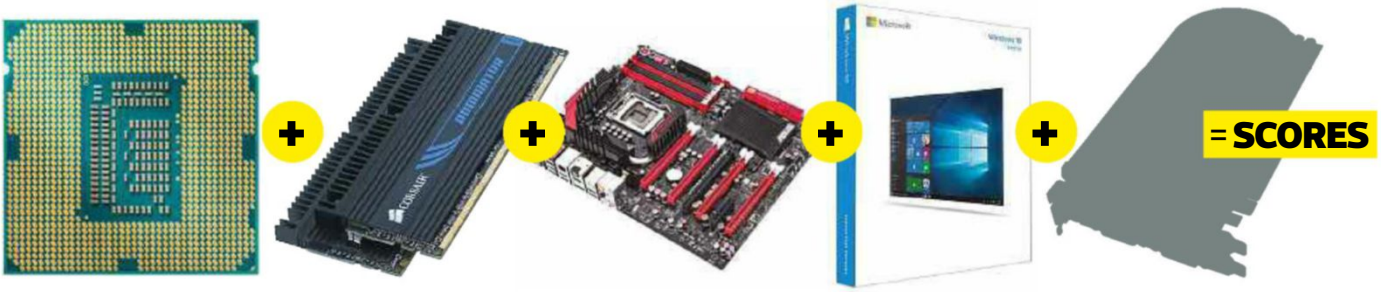


Intel LGA2011-v3 CPU | Asus Rampage V Extreme 10 Edition | 32GB Corsair Vengeance LPX 2666MHz DDR4 | Samsung SSD 850 Pro | AMD Radeon R9 390X | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.



4.2GHz Intel Core i5-3570K | 8GB Corsair Dominator 2400MHz DDR3 | Asus Maximus V Extreme | Windows 10 64-bit | The graphics card we're reviewing

CUSTOM PC REALBENCH 2015

INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB

AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

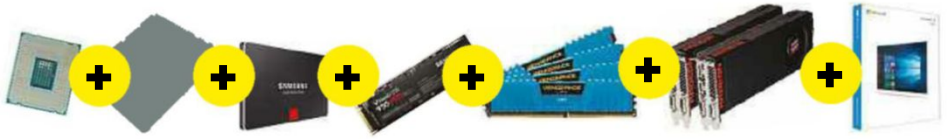
MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1151

Intel Core i7-6700K | Motherboard on test | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100 | AMD Radeon R9 390X | Windows 10 64-bit

INTEL LGA2011-V3



Intel Core i7-6850K | Motherboard on test | Samsung SSD 850 Pro | Samsung SSD 950 Pro | 32GB Corsair Vengeance LPX 3200MHz DDR4 | 2 x AMD Radeon R9 390X | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015 and Total War: Warhammer, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum base clock as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

TESTS: By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test Doom, Crysis 3, Fallout 4 and The Witcher 3: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

The Awards

EXTREME ULTRA
Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.

PREMIUM GRADE
Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.

PROFESSIONAL
Products worthy of the Professional award make you and your business appear even more awesome.

APPROVED
Approved products are those that do a great job for the money; they're the canny purchase for a great PC.

CUSTOM KIT
For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

LABS TEST

SATAclysm

Still the cheapest route to solid state storage, and usually fast enough for most people's needs, Edward Chester puts several 2.5in SATA SSDs to the test

Contents

Crucial MX300 525GB/p41
Crucial MX300 1TB/p41
Kingston UV400 480GB/p42
Samsung 750 Evo 500GB/p43
Samsung 850 Evo 120GB/p44
Samsung 850 Evo 500GB/p45
Samsung 850 Pro 256GB/p46
Samsung 850 Pro 512GB/p46
SanDisk Extreme Pro 480GB/p47
Results graphs/p48

How we test

Our first test is CrystalDiskMark, a freely available synthetic benchmark. We test at queue depths of both 1 and 32 – the former is the most relevant for regular users, while the latter is more representative of intensive workloads. We use the default settings but set the 32-queue-depth random test to use four CPU threads. Each test is run five times and we report the average.

Next up are two 'real-world' benchmarks PCMark 7 and PCMark 8, which both have storage tests that use genuine SATA trace data from applications such as Windows Defender and Battlefield 3. For PCMark 7, we only report the final overall score, but for PCMark 8 we also compare the data for the Battlefield 3, Microsoft Word and Photoshop Heavy tests. All these tests are run three times and we report the averages.

In order to gauge how an SSD will cope with more intense workloads, we also run Iometer to record the number of in/out operations per second (IOPS), as well as the average response time.

Finally, we test the boot speed using the freely available BootRacer app. Each drive is loaded with a fresh install of Windows 10 64-bit and a full set of drivers. We then refresh the system five times to allow Windows to sort out its caching, before using BootRacer to perform five cold starts to find out how fast the system boots. Next, we take the average time of five fast startups, which is where the system boots from a standby-like state, with Windows saving the operating system state to a hibernation file. This process results in a quicker boot time, as Windows doesn't have to reload the kernel, drivers and system state individually – it's the default Windows 10 shutdown behaviour. All tests are performed on an Asus Z-170A motherboard with an Intel Core i5-6600K and 16GB of Corsair Vengeance LPX 2666MHz DDR4 RAM.

The speed score is based on a weighted breakdown of the performance tests. CrystalDiskMark accounts for 30 per cent of this score (with a heavier weighting on low-queue-depth results), while 70 per cent of it is allocated to the PCMark 7, PCMark 8 and BootRacer real-world tests, as they're the most relevant for everyday use. The pound per gigabyte (£/GB) score is based on the pricing at the time of writing, divided by the accessible formatted capacity, while the bang per buck score is essentially a ratio of the speed and £/GB metrics.

Crucial MX300 525GB / £120 inc VAT
Crucial MX300 1TB / £240 inc VAT

USABLE CAPACITY 488GB and 977GB / **SUPPLIER** www.ebuyer.com

Crucial's new MX300 line-up is the first to feature Micron's new 3D TLC NAND. A full two years after Samsung first unveiled its own 3D NAND technology, Micron – Crucial's parent company – has finally joined the party.

The move to a 3D arrangement instantly triples density when compared with the company's conventional 2D or planar NAND. This situation should help to push down SSD prices, while pushing up capacities, as Samsung now has some competition. Right now, though, the MX300 isn't exactly gunning for the current 3D TLC champion, the Samsung 850 Evo. Instead, it's priced a little lower, and a quick glance at this drive's specs shows it isn't likely to be taking the performance crown from Samsung.

The maximum sequential read and write speeds of 530MB/sec and 510MB/sec are below the Samsung 850 Evo series' 540MB/sec and 520MB/sec speeds, and likewise the 4KB random speeds of 92K IOPS and 83K IOPS are below the 94K IOPS and 88K IOPS from the Samsung 850 Evo line. Similarly, the MX300 only gets a three-year warranty rather than the five-year deal that comes with the Samsung drives.

Otherwise, though, the MX300 drives are well placed to bring respectable performance at a competitive price. Also, you get all the usual features you expect at this level, including encryption support, SLC caching for faster initial write speeds and partial power loss protection.

SLC caching is dubbed Dynamic Write Acceleration in this case and, as its name suggests, it varies the size of the cache in line with the amount of free space on a drive. In contrast, Samsung's drives use a fixed-size cache. The ultimate effect is the same though: up to a certain amount – say 8GB – the drive will have faster write speeds then it will drop to a lower level until the drive has a chance to move data from the cache to longer-term storage in TLC NAND.

The drive itself looks smart, with an all-aluminium outer casing and a Crucial sticker that should be easy enough to remove if you'd rather just see the plain metal. In the box you also get a plastic riser to enable the 7mm drive to fit more securely in 9mm drive bays, plus there's a code for Acronis True Image HD. The latter is a decent inclusion that will allow you to perform a full drive-level transfer of your data from your old drive to the new one, as well as perform other partitioning tricks.

In our tests, the MX300 performed pretty much as expected, sitting between the fastest and slowest drives on test. The differences are small, but there are certain telltale signs of how the drive will feel in everyday use. For a start, the 32-queue-depth read and write speeds indicated in CrystalDiskMark show the faster drives hitting around 400MB/sec read and 360MB/sec write. The MX300, though, hits around 380MB/sec and 340MB/sec, while the Kingston UV400 – the slowest drive on test – manages 350MB/sec and 340MB/sec.

> Crucial's new MX300 line-up is the first to feature Micron's new 3D TLC NAND

The trend continues with the PCMark tests, but when it comes to boot times, the MX300 actually comes last. When pushed a little harder in our Iometer tests, the MX300 fell a little behind some of the competition too, including Samsung's 2D TLC-based (and identically priced) 750 Evo 500GB.

Conclusion

Crucial's MX300 drives are a bit of a disappointment after the company's previous MX100 and BX100 drives fared so well in our reviews – we were expecting more from the company's first 3D TLC NAND. The performance differences aren't massive, and you get an attractively designed drive and a good set of features, but the prices of these drives need to drop if they're going find their niche.

VERDICT

Decent enough drives, but the price makes them uncompetitive for the performance on offer.

CRUCIAL MX300 525GB

SPEED	£/GB	OVERALL SCORE
33/50	17/20	71%
BANG/BUCK		
21/30		

CRUCIAL MX300 1TB

SPEED	£/GB	OVERALL SCORE
33/50	17/20	71%
BANG/BUCK		
21/30		

Kingston UV400 480GB / £100 inc VAT

USABLE CAPACITY 447GB / **SUPPLIER** www.overclockers.co.uk

Kingston's UV400 is the cheapest drive on test, with this 480GB model available for under £100 at the time of writing. It is, however, a brand-new drive that's only arrived in the past few months, so it's not just old tech being sold off at discount. Instead, it uses Toshiba's latest 15nm 2D planar TLC NAND coupled with a Marvell 88SS1074 4-channel controller. This setup enables the range to offer up to 550MB/sec read and 500MB/sec write for sequential performance, and 90,000 and 50,000 IOPS for random 4KB read/write operations.

We were only able to get the 480GB drive in time for this group test. However, that's sure to be the choice drive for people considering this range, so it will give us a good indication of the performance buyers should expect. Otherwise, you can also pick the drive up in 120GB, 240GB and 960GB variants.

Like most TLC SSDs, a portion of the UV400's NAND is configured to run in SLC mode, which allows for much faster write speeds. Once it's full, though, performance drops off as data is written to the slower TLC NAND. On this 480GB version, that SLC portion is around 8GB in size according to our tests.

As such, unless you're regularly copying files larger than 8GB to your SSD, you shouldn't see performance slowing down.

The drive itself looks great, with an all-metal outer casing that has a rough, sand-blasted finish. A painted Kingston logo means you can't just peel off a sticker for a minimalist look, but the logo is tidy, with no extra information cluttering up the front. The basic drive comes with no extras, as you'd expect given its low price.

However, an upgrade kit version is also available (pictured), which provides all the cables, drive mounts and software you'll need to upgrade. It costs about £20 more than the basic version. All versions of the drive come with a three-year warranty.

The drive looks great, with an all-metal outer casing that has a rough, sand-blasted finish

When it comes to testing, the UV400's performance deficit is clear across the board. However, in many benchmarks, it still holds its own. Initial sequential read and write speeds are around 510MB/sec and 490MB/sec respectively while 4KB random read and writes aren't too far behind the competition.

However, a quick large file transfer test reveals that sequential write performance really drops when that SLC cache is full, down to around 90MB/sec. That isn't atypical for entry-level drives, but comparatively, the MX300 settled on around 300MB/sec in the same test. Hit the drive with even more intensive workloads and it really struggles, as you'll find with most planar TLC NAND drives.

However, the real-world feel of this drive for many users won't be a great deal worse than any of the others on test, simply because of the limitations of the SATA interface. It was mainly during our intense Iometer tests that we really noticed the drive slowing down. The UV400 clearly isn't a bargain option for anyone requiring consistently high levels of performance.

Conclusion

Kingston's UV400 drive offers good overall performance if you're simply looking to upgrade from a hard drive. However, its limitations are clear. If you regularly move around large files, you'll come up against its slow sustained write speeds, and power users will find its overall performance a little limiting. Still, with such a low asking price for 480GB of solid state storage, it's definitely a viable option for anyone seeking the largest capacity SSD for the least amount of money.

VERDICT

The UV400 doesn't set the world of SSD performance alight, but it's a decent SSD for a rock-bottom price.

SPEED	£/GB	OVERALL SCORE
29/50	19/20	70%
BANG/BUCK		
22/30		

Samsung 750 Evo 500GB / £120 inc VAT

USABLE CAPACITY 465GB / **SUPPLIER** www.ebuyer.com

Samsung has become known for dominating the entire spectrum of consumer SSDs over the past few years, partly thanks to it being the first company to market with 3D NAND. However, what really kicked off the company's SSD success was its 2D planar TLC NAND, which was used in the hugely successful 840 Evo range.

The strength of Samsung's controllers, when coupled with this densely packed NAND, allowed for great performance and a competitive price. Meanwhile, other competitors were stuck using less dense, and thus pricier, two-level MLC NAND. Since then, Samsung has continued to work on its planar TLC NAND while also continuing its development of 3D NAND products, and the result of that development is its new entry-level drive, the 750 Evo. In contrast, Micron is set to completely abandon planar NAND use in SSDs.

Essentially an upgraded version of the 840 Evo, the 750 Evo uses the latest 16nm TLC NAND, as opposed to the 19nm TLC used in the 840 Evo. It also uses Samsung's latest controller, so it doesn't suffer from the same speed degradation problems of Samsung's 840 Evo drives.

The upshot is a drive series that's essentially aimed at the likes of the Kingston UV400, although right now, it's priced just a little higher, with this 500GB drive costing £114 compared to the Kingston drive's £100 price. Of course, the Kingston has a slightly lower capacity, but it does still come out on top for value.

The drive itself uses Samsung's signature colour scheme of black-painted metal casing with a coloured square indicating the drive's class – grey for Evo, red for Pro. Here, the logo is printed on the chassis, so you can't remove it, but it at least looks attractive and understated in the first place.

> Essentially an upgraded 840 Evo, the 750 Evo uses the latest 16nm TLC NAND

You get no extras in the box, such as a 7mm to 9mm riser, but you can download Samsung's Magician and Data Migration software for free. These utilities enable easy monitoring and firmware upgrades of your SSD, and enable you to migrate your data from your old drive to the new one. There's no mention of either utility on the box, but they're easy to find on Samsung's website.

When it comes to performance, the 750 Evo initially impressed. This drive, at least in its 500GB form, comfortably competes with mid-range drives. However, the 750 Evo starts to struggle in more intensive workloads. While it's one of the fastest planar TLC drives available for light use, it slows down in any situation where its cache is full and it's running at steady-state performance. You can see in our Iometer tests that the 750 Evo really starts to fall behind the Samsung 850 Pro drives, and the 850 Evo 500GB, when it has to work hard.

Nevertheless, this drive wasn't designed to cope with such scenarios. If you're really hammering your SSD – regularly importing masses of photos while simultaneously editing video, running backups and running a virus scan and so on, then you'll want to move to a higher class of drive.

As such, the Evo 750 manages to find a good niche for itself, as the fastest entry-level drive that's still comfortably cheaper than the likes of the 850 Evo, just as long as you know its limitations.

Conclusion

Push the Samsung 750 Evo hard and it starts to struggle, but in more regular workloads, it's the best in its class. This situation might not be clear-cut, but it's still easy to judge this drive in terms of who should buy it. If you're primarily just gaming and doing light desktop work, then it's a good buy, but if you regularly push your PC then other, more expensive SATA drives will handle the workload better.

VERDICT

The fastest 2D TLC drive we've tested, but don't push it too hard.

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
35/50	18/20	20/30	73%

Samsung 850 Evo 120GB / £48 inc VAT
Samsung 850 Evo 500GB / £133 inc VAT

USABLE CAPACITY 111GB and 465GB / **SUPPLIER** www.currys.co.uk

The Samsung 850 Evo has been the go-to mid-range drive ever since it launched nearly two years ago. Its debut combined 3D TLC NAND with Samsung's excellent controller, providing such a great balance of price and performance that its dominance hasn't let up since. So is it still the best choice? Let's first recap what's on offer here.

Available in capacities from 120GB up to 4TB, the 850 Evo has a class-leading five-year warranty and impressive overall performance figures. All drives come with at least 540MB/sec and 520MB/sec sequential read and write speeds.

As with other TLC SSDs, Samsung dedicates a portion of the NAND for use in SLC mode, for faster write operations. The size of that portion varies with the size of the drive, from 3GB for the 120GB drive and up to 12GB for the 1TB drive.

Once filled, the write speed drops back down to 150MB/sec for the 120GB drive, 300MB/sec for 250GB and 500GB and 500MB/sec for the rest of the range.

Each drive also contains a portion of DRAM to help keep operation moving swiftly while the controller works at retrieving and writing data as efficiently as possible. The size of this portion varies from 256MB to 4GB.

The latest addition to Samsung's SSD 850 Evo line-up, the £1,200, 4TB version uses a new generation of 48-layer V-NAND that comes in 256Gb packages.

However, the rest of the range continues to use the existing 32-layer V-NAND. Both packages continue to be produced using a 16nm process though.

The new 4TB version also uses the MHX controller as used on the 2TB version, but all the other drives use the MGX controller. The lower capacities drop to a 2-core version of it, while higher-capacity drives have a 3-core configuration.

The drives themselves look almost identical to the 750 Evo range, with the same black finish and grey square. However, on the 850 drives, the Samsung logo is silver rather than grey. As with the 750, you also get no extras but you have access to Samsung's free software on the website.

When it comes to performance, the 850 Evo hasn't lost its touch. We tested the 120GB and 500GB versions, and both still impress, although the 500GB is definitely the superior drive, being quicker and offering more for your money. Right across the board, these drives beat any other families of budget or mid-range drives and even exchange a few first places with high-end drives.

However, our Iometer tests show where these drives start struggling – the 500GB 850 Evo will take a fair old hammering, but professional tier drives maintain faster performance in these tests. That said, all cheaper drives struggle when put under sustained intensive workloads, and the 500GB 850 Evo holds up much better than the rest.

As such, the only real factor here is that Samsung charges a substantial premium for these drives. Justified though it may be in many ways, the 500GB drive costs £35 more than the 480GB Kingston UV400.

If the only real strain you're ever putting on your system is gaming, that money could be better spent elsewhere.

Conclusion

The Samsung 850 Evo range continues to reign supreme, offering the ideal balance of cost and performance. The 500GB drive in particular comfortably outperforms entry-level and mid-range drives, and while it trails the fastest drives, it only does so under the harshest of conditions. As such, it remains the go-to choice for most home users and gamers.

VERDICT

Two years on, the Samsung 850 Evo series is still top dog for the majority of home users and gamers.

SAMSUNG 850 EVO 120GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
40/50	12/20	22/30	74%

SAMSUNG 850 EVO 500GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
45/50	17/20	26/30	88%

COOLER MASTER

Make It Yours.

The Best of Both Worlds

MASTERKEYS PRO L / S

16.7 Million colors
RGB Per Key Backlighting

Cherry MX Brown switch

Most RGB keyboards make you compromise with either bright LEDs or high-quality switches. But with the full MasterKeys Pro L and tenkeyless MasterKeys Pro S keyboards, you get the best of both worlds: the brightest LEDs and the best tactile feeling that gamers have come to love. How is this possible?

We completely redesigned the interior to fit both Cherry MX switches and bright LEDs that can radiate 16.7 million colors. You also get on-the-fly macros, profile support, and easy-to-use software - all in a sleek, minimalistic design.

Learn More at coolermaster.co.uk

coolermaster.co.uk

Samsung 850 Pro 256GB / £124 inc VAT
Samsung 850 Pro 512GB / £215 inc VAT

USABLE CAPACITY 238GB and 476GB / **SSUPPLIER** www.scan.co.uk

Just as Samsung's 850 Evo line has been one of the top choices for mainstream users for two years, the Samsung's 850 Pro line been among the best choices for ultimate performance. Originally only available in sizes up to 1TB, the line-up has since expanded to include a 2TB version that demands a whopping £800 or so. Meanwhile, down at more sensible levels, the 512GB version still goes for £215 inc VAT, over double the price of the cheapest 500GB drive on test.

For that extra cash, though, you get the level of performance and extras you'd expect. Samsung claims 550MB/sec and 520MB/sec sequential read and write speeds for all but the 128GB model, which drops to a 470MB/sec write speed. What's more, with no SLC cache required to obtain fast write speeds, you don't get a drop in prolonged write speeds and you also get the full 512GB capacity of the NAND, rather than the 500GB on an equivalent TLC NAND-based drive.

The use of MLC also contributes to a high endurance rating of 150TB for the 128GB and 256GB models, and 300TB for the larger drives. Plus, the warranty lasts for a whopping ten years. The NAND used in the Pro drives is Samsung's 32-layer MLC V-NAND, which is managed by either Samsung's MEX or MHX controller, coupled with 256MB-2GB of DRAM, depending on capacity.

A little extra effort has gone into the looks too. Although the Pro has the same metal casing as the other Samsung drives, the top has been bevelled to create a neat shiny line around the top of the drive. Otherwise, you get the same painted-on Samsung logo and red 'Pro' square. In the box, you don't get any extras such as a 7-9mm riser, but you do get a CD containing Samsung's SSD software, or you can just download the latest versions from Samsung's website.

In many benchmarks it isn't overly clear why you'd pay the premium for such a high-end drive when it's limited by the SATA interface.

Nearly all our tests show the 850 Pro sitting within a few percentage points of all but the slowest of drives.

However, while the 256GB version is a touch slow, the 512GB model is second only to the SanDisk Extreme Pro for boot times, while sequential read and write speeds are the best in its league.

What's more, a sustained write test shows just how much faster these drives can get when the going gets tough, with no drop-off from its initial figure even after many GB have been written to the drive.

Put the drive under even greater sustained, mixed read/write loads and the differences are really marked. In our Iometer tests you can really see the performance difference when you start to hammer these drives.

What situations will provide that much stress? Realistically, you're talking about busy server applications, but users that really hammer their systems, running multiple data-IO heavy apps at once – or just regularly moving large files around – will see the benefit. Plus you get the reassurance of a ten-year warranty and that extra NAND endurance.

Conclusion

The Samsung 850 Pro is undoubtedly the fastest SATA SSD on the market. It's nip and tuck with the SanDisk Extreme Pro, but it ultimately comes out on top, and it's great to see capacities over 1TB too, even if they demand a hefty premium. Only a select few users actually need the performance provided by the Pro, but if that's you, it delivers the goods if you're prepared to pay the extra cash.

VERDICT

Although it's pricier than the SanDisk Extreme Pro, the Samsung 850 Pro claims the performance top spot under intense workloads, while offering high endurance.

SAMSUNG 850 PRO 256GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
48/50	10/20	15/30	73%

SAMSUNG 850 PRO 512GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
49/50	17/20	20/30	86%

SanDisk Extreme Pro 480GB / £158 inc VAT

USABLE CAPACITY 446GB / **SUPPLIER** www.amazon.co.uk

Like the Samsung 850 drives, the SanDisk Extreme Pro bas been around for a couple of years, and there isn't even a new higher-capacity model to spice up the series. Instead you just get 240GB, 480GB and 960GB versions. That may seem like it puts the Extreme Pro at a disadvantage, but a quick glance at prices redresses that balance. While the 1TB Samsung 850 Pro costs £380 or more, the 960GB Extreme Pro is £312. That's a big saving.

In most areas relevant to enthusiasts, the Extreme Pro can compete with the Samsung drives for features too. You get impressive performance figures, a long ten-year warranty and low power draw. SanDisk claims sequential speeds of 550MB/sec read and either 520MB/sec or 515MB/sec write depending on capacity. Meanwhile, 4KB random read and write figures are 100K IOPS and 90K IOPS for all capacities.

There are a few potential key areas where it can't keep up though. There's no hardware encryption, so anyone concerned about security will have to look elsewhere.

Also, endurance is rated at 80TB, which is by no means low but trails the Samsung 850 Pro drives.

The drives are built using SanDisk's second-generation 64Gb 19nm MLC NAND, so there's no fancy 3D or TLC here. However, there's still a small amount of SLC caching going on, which SanDisk calls nCache Pro. It isn't traditional SLC caching, as there's only 1GB of it. Instead, it acts in conjunction with the DRAM to better manage data transition between long-term MLC NAND and your system. As such, there should be no performance drop-off. Meanwhile, the controller is a Marvell 88SS9187, which is coupled with either 512MB or 1GB of DRAM, depending on the drive's capacity.

The drive's appearance is fairly mundane. It has a plastic top, with an ugly cutaway for the SATA connection, plus a fairly dull sticker, making it arguably the least attractive drive on test. You do at least get a plastic riser for fitting the 7mm drive into 9mm bays, though, plus SanDisk has its own software called SanDisk SSD Dashboard, which makes firmware updates easy and allows you to monitor other attributes of the drive.

> There's still a small amount of SLC caching, which SanDisk calls nCache Pro

The Extreme Pro doesn't disappoint in performance tests though. It battles back and forth with the Samsung 850 Pro drives for the top spot throughout our tests, including an overall win for boot speed. Samsung's models just claim the top spot for the PCMark tests and indeed come out on top overall, but only by a small margin.

As such, once cost is taken into account, the SanDisk Extreme Pro is arguably the best value high-end SATA drive on the market. For just £8 more than the 500GB Samsung 850 Evo, you can get the markedly more consistently fast 480GB Extreme Pro, while the 850 Pro is another £22 more. Meanwhile, at around 1TB, the price differences rise to £22 and £67.

The relevance of those differences will come down to how you use your SSD and how much money you have to spend – if you're spending £200-£300 on an SSD, what's another £50 or so? Either way, the SanDisk Extreme Pro offers excellent performance and good value for money, two years on from its launch.

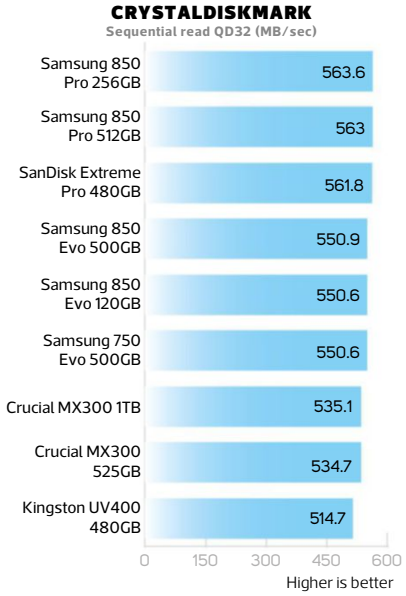
Conclusion

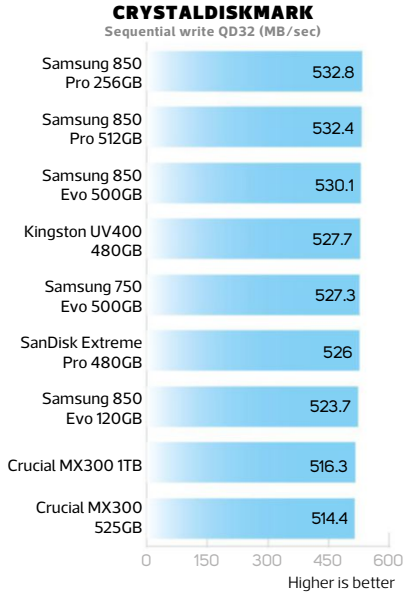
Not everyone needs the performance the SanDisk Extreme Pro provides. What's more, if you want the very best speed, the 850 Pro just pips it to the post. However, thanks to aggressive pricing, the Extreme Pro comes out on top when it comes to value at the high end of SATA SSD performance. Assuming you don't mind about not getting encryption, it's an impressively fast SSD for the money.

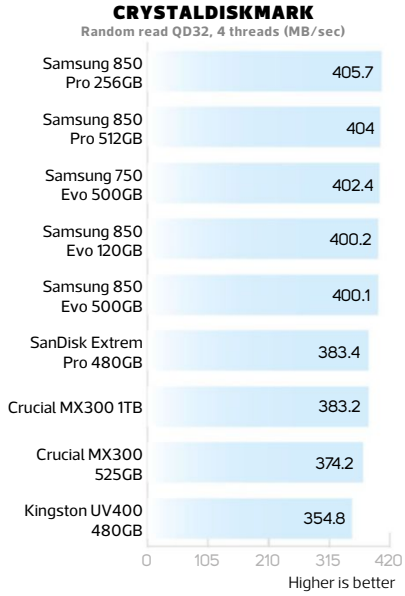
VERDICT

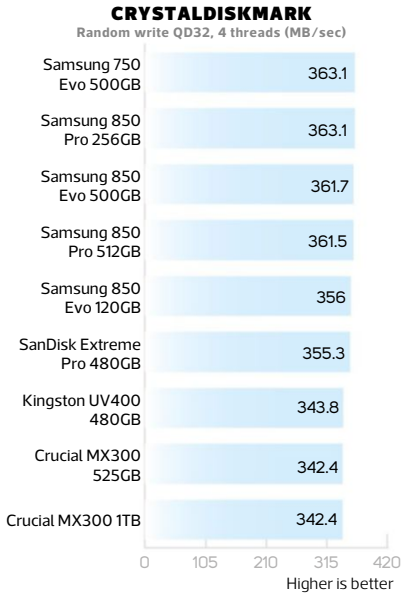
Not quite the fastest SSD on the market, but aggressive pricing means it's still very quick for the money.

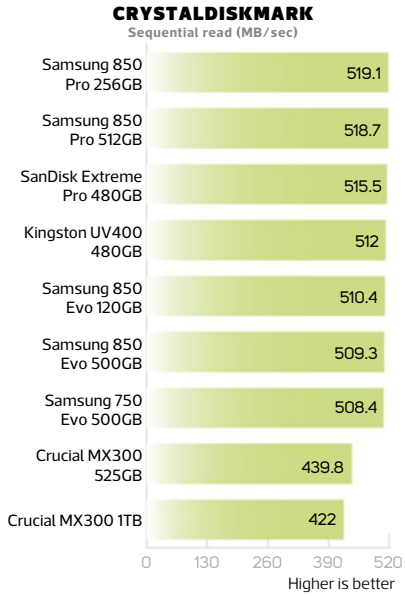
SPEED	£/GB	BANG/BUCK	OVERALL SCORE
46/50	16/20	25/30	87%

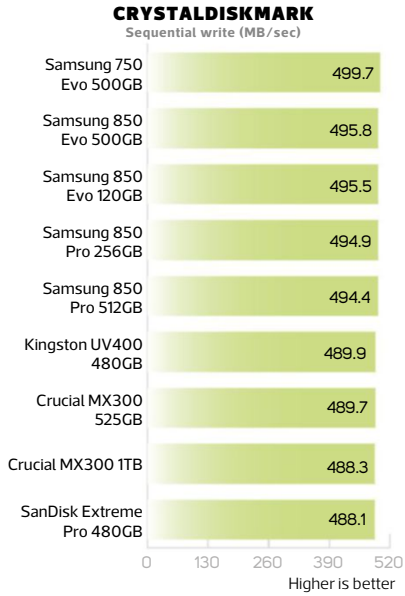

CRYSTALDISKMARK
Sequential read QD32 (MB/sec)
Samsung 850 Pro 256GB 563.6
Samsung 850 Pro 512GB 563
SanDisk Extreme Pro 480GB 561.8
Samsung 850 Evo 500GB 550.9
Samsung 850 Evo 120GB 550.6
Samsung 750 Evo 500GB 550.6
Crucial MX300 1TB 535.1
Crucial MX300 525GB 534.7
Kingston UV400 480GB 514.7
0 150 300 450 600
Higher is better

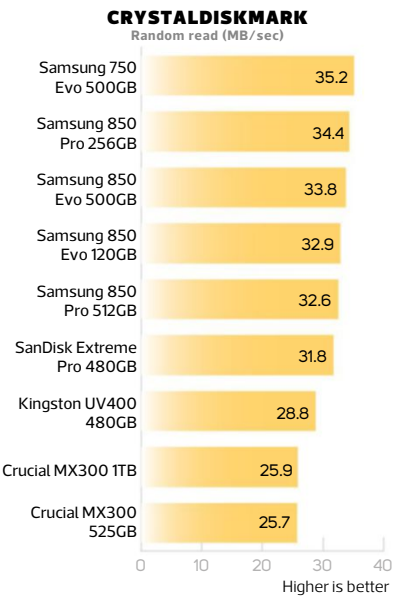

CRYSTALDISKMARK
Sequential write QD32 (MB/sec)
Samsung 850 Pro 256GB 532.8
Samsung 850 Pro 512GB 532.4
Samsung 850 Evo 500GB 530.1
Kingston UV400 480GB 527.7
Samsung 750 Evo 500GB 527.3
SanDisk Extreme Pro 480GB 526
Samsung 850 Evo 120GB 523.7
Crucial MX300 1TB 516.3
Crucial MX300 525GB 514.4
0 150 300 450 600
Higher is better

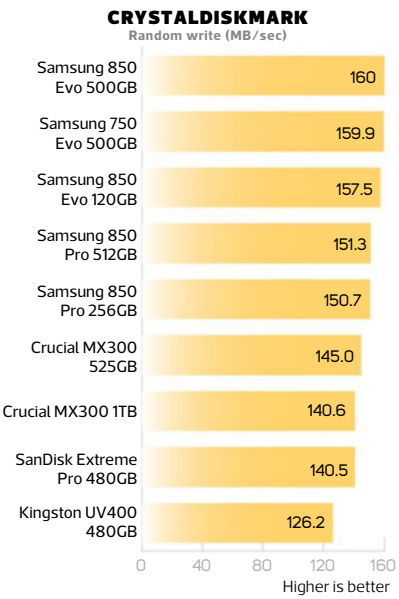

CRYSTALDISKMARK
Random read QD32, 4 threads (MB/sec)
Samsung 850 Pro 256GB 405.7
Samsung 850 Pro 512GB 404
Samsung 750 Evo 500GB 402.4
Samsung 850 Evo 120GB 400.2
Samsung 850 Evo 500GB 400.1
SanDisk Extrem Pro 480GB 383.4
Crucial MX300 1TB 383.2
Crucial MX300 525GB 374.2
Kingston UV400 480GB 354.8
0 105 210 315 420
Higher is better


CRYSTALDISKMARK
Random write QD32, 4 threads (MB/sec)
Samsung 750 Evo 500GB 363.1
Samsung 850 Pro 256GB 363.1
Samsung 850 Evo 500GB 361.7
Samsung 850 Pro 512GB 361.5
Samsung 850 Evo 120GB 356
SanDisk Extreme Pro 480GB 355.3
Kingston UV400 480GB 343.8
Crucial MX300 525GB 342.4
Crucial MX300 1TB 342.4
0 105 210 315 420
Higher is better


CRYSTALDISKMARK
Sequential read (MB/sec)
Samsung 850 Pro 256GB 519.1
Samsung 850 Pro 512GB 518.7
SanDisk Extreme Pro 480GB 515.5
Kingston UV400 480GB 512
Samsung 850 Evo 120GB 510.4
Samsung 850 Evo 500GB 509.3
Samsung 750 Evo 500GB 508.4
Crucial MX300 525GB 439.8
Crucial MX300 1TB 422
0 130 260 390 520
Higher is better

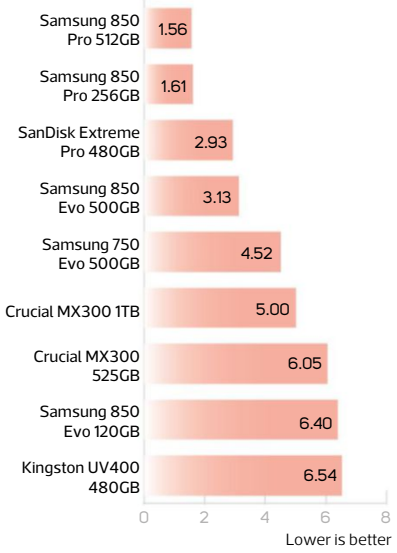

CRYSTALDISKMARK
Sequential write (MB/sec)
Samsung 750 Evo 500GB 499.7
Samsung 850 Evo 500GB 495.8
Samsung 850 Evo 120GB 495.5
Samsung 850 Pro 256GB 494.9
Samsung 850 Pro 512GB 494.4
Kingston UV400 480GB 489.9
Crucial MX300 525GB 489.7
Crucial MX300 1TB 488.3
SanDisk Extreme Pro 480GB 488.1
0 130 260 390 520
Higher is better


CRYSTALDISKMARK
Random read (MB/sec)
Samsung 750 Evo 500GB 35.2
Samsung 850 Pro 256GB 34.4
Samsung 850 Evo 500GB 33.8
Samsung 850 Evo 120GB 32.9
Samsung 850 Pro 512GB 32.6
SanDisk Extreme Pro 480GB 31.8
Kingston UV400 480GB 28.8
Crucial MX300 1TB 25.9
Crucial MX300 525GB 25.7
0 10 20 30 40
Higher is better


CRYSTALDISKMARK
Random write (MB/sec)
Samsung 850 Evo 500GB 160
Samsung 750 Evo 500GB 159.9
Samsung 850 Evo 120GB 157.5
Samsung 850 Pro 512GB 151.3
Samsung 850 Pro 256GB 150.7
Crucial MX300 525GB 145.0
Crucial MX300 1TB 140.6
SanDisk Extreme Pro 480GB 140.5
Kingston UV400 480GB 126.2
0 40 80 120 160
Higher is better

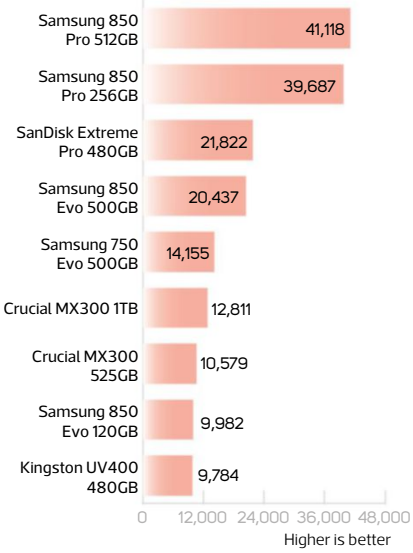
IOMETER - 4KB RANDOM WRITES

Average response time (ms)



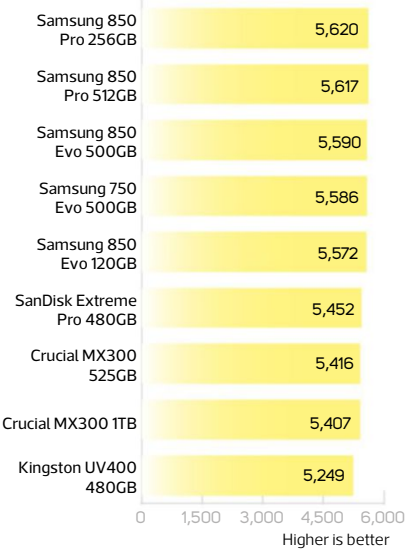
IOMETER - 4KB RANDOM WRITES

IO operations per second



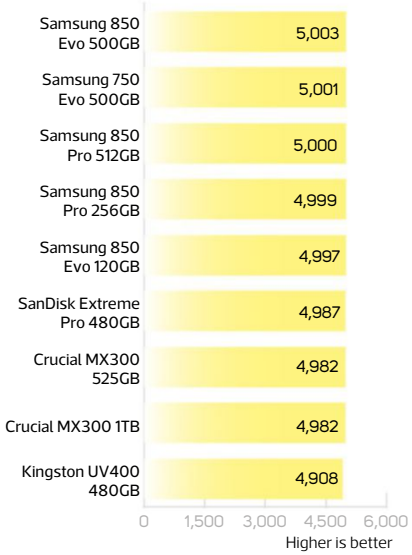
PCMARK 7

Secondary Storage score



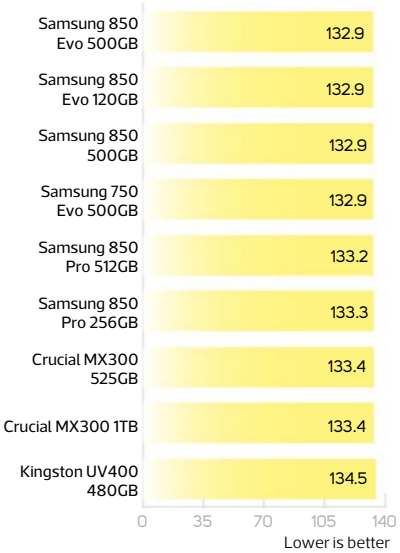
PCMARK 8

Overall



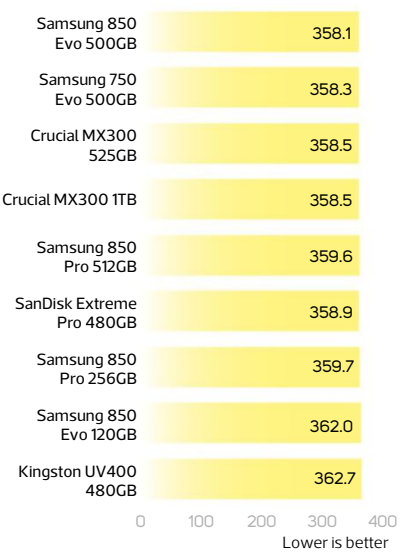
PCMARK 8

Battlefield 3 trace (seconds)



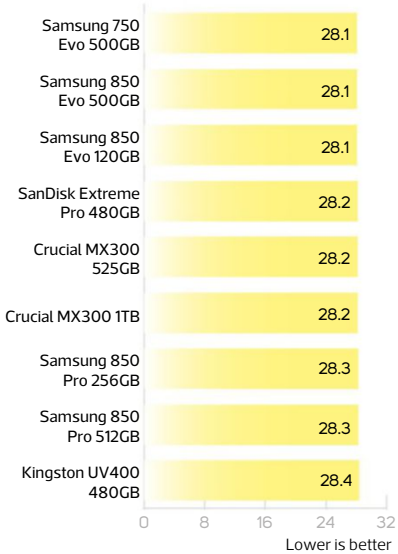
PCMARK 8

Photoshop Heavy trace (seconds)



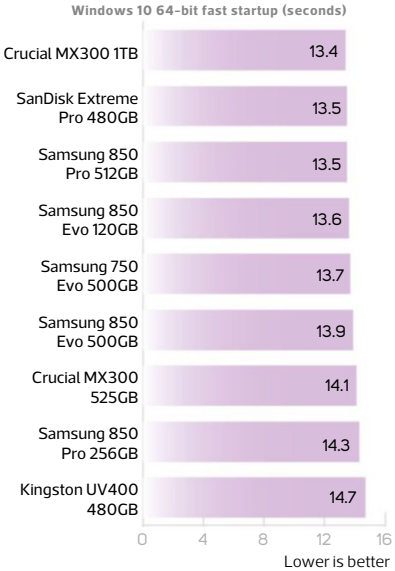
PCMARK 8

Microsoft Word trace (seconds)



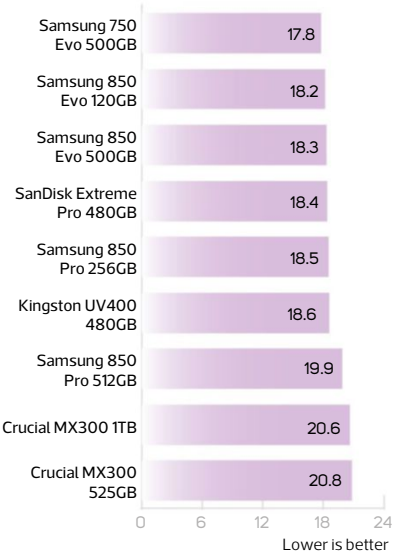
BOOTRACER

Windows 10 64-bit fast startup (seconds)



BOOTRACER

Windows 10 64-bit cold boot (seconds)



LABS TEST

Memory lane

Antony Leather tests 12 dual-channel 16GB DDR4 memory kits, rated at 2666MHz and over 3000MHz, to sort the gems from the stones

Contents

2666MHz DDR4 memory

Avexir Impact / p51
Corsair Vengeance LPX / p51
Crucial Ballistix Tactical / p52
G.Skill Ripjaws V / p52
Geil Dragon RAM / p53
HyperX Savage Black / p53

3000MHz+ DDR4 memory

Corsair Vengeance LED / p56
Crucial Ballistix Tactical / p56
G.Skill Trident Z / p57
Geil Dragon RAM / p57
Patriot Viper Elite Series / p58
Team Group Dark Pro / p58

Single-channel vs dual-channel memory / p54
Frequency vs timings / p54
Results graphs / p59

How we test

We've put six 2666Mhz and six 3000MHz+ 16GB dual-channel DDR4 memory kits through their paces in two separate group tests. Each kit is tested using the standard XMP profile, which loads the correct timings and frequency, which we cross-checked in the EFI of our ASRock Z170 Extreme4 motherboard. The rest of our test system comprises an Intel Core i5-6600K CPU, a Corsair AX860i PSU, an Nvidia GeForce GTX 1060 6GB graphics card, an NZXT Kraken X41 cooler and a 512GB Crucial MX100 SSD.

We tested each memory kit in our RealBench test suite, testing performance in image editing, video encoding and multi-tasking. In addition, we also obtained a score in Cinebench R15 to assess rendering performance, and in Crysis 3 to gauge any differences in games. We also overclocked each kit, leaving its timings at stock, but increasing the voltage to 1.4V and obtaining the highest stable frequency that allowed Prime95's blend test to run for 15 minutes without any issues.

Performance is very similar between memory kits. In fact, at specific timings and frequencies, the performance should be identical, so we've listed the maximum frequency each kit obtained in the graphs, rather than retesting each kit at its overclocked frequency. That way, you can quickly see which kits are the best overclockers, whether you're benchmarking or maximising performance.

The performance score is based on the benchmark results, with an above average weighting given to the size of the overclock. As performance is so similar, we also award a score for the design of the memory, with features such as LED lighting or painted PCBs gaining extra marks.

The value score is then a weighted calculation based on the performance and design scores, which also accounts for the price, with the final score being the sum of all three scores as a percentage.

Avexir Impact / £130 inc VAT

SUPPLIER www.overclockers.co.uk / **MODEL NUMBER** AVD4UZ126661508G-2IPROG

We've seen lights on RAM for many years, but Avexir is taking RAM lighting to a new level. We were sadly unable to get hold of its Raiden memory, with its snazzy light tube, but we did manage to snag its Impact memory, which has a pulsing LED strip on its top, covered with a length of red acrylic. It looks fantastic, even when it isn't illuminated, with its compact (it measures less than 39mm in height), chunky design.

When powered up, the DIMMs take turns in pulsing on and off in a subtle lighting display. The name suggests it might pair well with Asus' premium mini-ITX motherboard, and it has an Asus ROG-style look, with colour-coded red, black and silver details.

Our Avexir Impact was also an overclocking demon too, managing a staggering 800MHz overclock – enough to match the best overclocks from our group of 3000MHz+ kits, all without raising the timings from their tight settings. The downside, though, is that this kit costs £130 inc VAT – more than any of the 3000MHz+ kits we tested this month, including Corsair's LED-equipped Vengeance LED.

While the Impact is extremely expensive for a 2666MHz kit, we were bowled over by its overclocking abilities and aesthetics. It's also ideal for any ROG fans, as it matches Asus' red and black colour scheme better than any other memory kit we've seen.

PERFORMANCE	DESIGN	VALUE
28/30	24/25	34/45

VERDICT

Pricey, but very overclockable and a great aesthetic match for Asus ROG motherboards.

OVERALL SCORE 86%

/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 15-15-15-35
- **Voltage** 1.2V
- **Height (from base)** 38.5mm
- **Lighting** Red LED

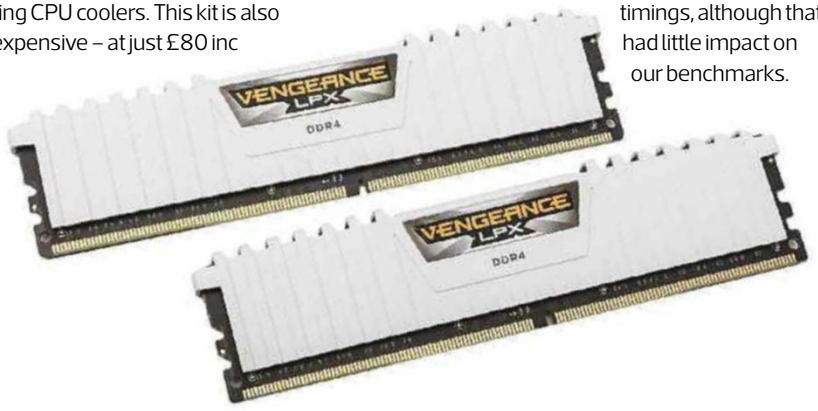
Corsair Vengeance LPX / £80 inc VAT

SUPPLIER www.scan.co.uk / **MODEL NUMBER** CMK16GX4M2A2666C16

Corsair's Vengeance memory has graced the pages of our Elite List for dozens of issues, but Corsair is up against some stiff competition in the 2666MHz market now, not least from its own Vengeance LED series, which only costs £5-10 more. However, the Vengeance LPX sticks still have a few advantages over other models on test this month.

For a start, they have a very low profile, standing less than 34mm tall, which is handy if you need it to squeeze them under low-riding CPU coolers. This kit is also inexpensive – at just £80 inc VAT it undercuts the Crucial Ballistix Tactical and Avexir Impact while matching the HyperX Savage. It's available in a range of colours to match your system as well, with the white and red models looking particularly attractive.

The Vengeance LPX holds up well to overclocking – we added an extra 534MHz to its stock frequency to reach 3200MHz at its standard timings, although the Avexir kit trumped this result, getting to 800MHz above its stock speed. The Vengeance LPX also has comparatively loose timings, although that had little impact on our benchmarks.



Corsair's Vengeance LPX memory is now showing its age, and while it's still a solid choice, there are now better options for the same cash, while Corsair's own Vengeance LED series costs just £6 more and looks fantastic.

PERFORMANCE	DESIGN	VALUE
25/30	16/25	39/45

VERDICT

Solid, low-profile RAM, but looking a little dated now and no longer offering the best value.

OVERALL SCORE 80%

/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 16-18-18-35
- **Voltage** 1.2V
- **Height (from base)** 33.5mm
- **Lighting** No

Crucial Ballistix Tactical / £84 inc VAT

SUPPLIER www.novatech.co.uk / **MODEL NUMBER** BLT2C8G4D26AFTA

Crucial has seemingly started to rein in its premium memory offerings, and only makes a few DDR4 kits that are rated beyond 2400MHz, such as this Ballistix Tactical kit. The modules look fairly attractive but basic, with dark grey metallic heatsinks. However, a number of other kits we've reviewed this month look much better, and without LEDs too, if you're more concerned about aesthetics.

The modules have a reasonably low profile at 37mm, although again, there are shorter kits on test. It doesn't have the tightest timings on test either, although it was only a tiny fraction slower than the competition in our benchmarks.

We managed to coax an additional 534MHz out of the Crucial Ballistix Tactical kit, using a voltage of 1.4V and leaving the timings alone, giving us a top frequency of 3200MHz. This result is the joint second best on test, only bettered by the much more expensive Avexir Impact kit (see p51).

However, despite this good overclock, there are cheaper kits that offer the same or better performance and specifications. The Ballistix Tactical is also outdone in the aesthetic department by similarly priced kits that offer better-looking heatsinks or LEDs. As such, while it's a solid effort, the Ballistix Tactical is in need of an overhaul or a price drop to be competitive.

PERFORMANCE	DESIGN	VALUE
25/30	19/25	34/45

VERDICT

A good overclocker, but the Ballistix Tactical needs a design revamp and a price drop.

OVERALL SCORE 78%

/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 16-17-17-36
- **Voltage** 1.2V
- **Height (from base)** 37mm
- **Lighting** No

G.Skill Ripjaws V / £73 inc VAT

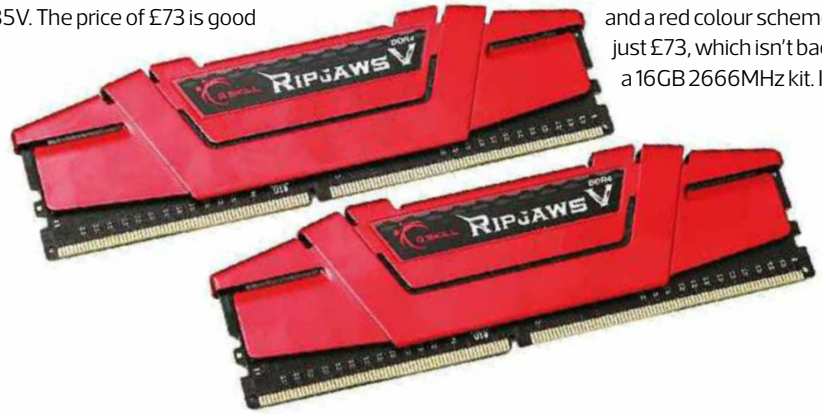
SUPPLIER www.amazon.co.uk / **MODEL NUMBER** F4-2666C15D-16GVR

While G.Skill's Ripjaws V modules might not offer the same top-notch aesthetics as their more expensive, faster siblings – the Trident Z series (see p57) – they've at least seen a slight design revamp since the original Ripjaws sticks, and now have a slightly sleeker heatsink, although the red colouring is a little garish.

The specs are good too, with very tight timings of 15-15-15-35 and, like most of the other 2666MHz kits on test this month, they only require 1.2V of voltage, as opposed to 1.35V. The price of £73 is good for a fully fledged, 16GB dual-channel kit as well, although it's only £1 behind the very swanky-looking Geil Dragon RAM (see p58).

The Ripjaws V modules proved to be great overclockers, rising from 2666MHz to 3200MHz with relative ease at 1.4V, while leaving the stock timings alone. This result betters the Crucial and HyperX kits, although the more expensive Avexir kit managed to get all the way to 3466MHz.

As a budget memory kit, the G.Skill Ripjaws offers decent overclocking and a red colour scheme for just £73, which isn't bad for a 16GB 2666MHz kit. Its only problem is that the better-looking Geil Dragon RAM kit costs just £1 more and has much shorter modules, albeit with slightly less overclocking headroom. If you can't find the Dragon RAM, though, this G.Skill Ripjaws V kit remains a solid, good-value choice.



PERFORMANCE	DESIGN	VALUE
25/30	16/25	42/45

VERDICT

A fantastic memory kit if you're on a tight budget, although the design is a little dated.

OVERALL SCORE 83%

/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 15-15-15-35
- **Voltage** 1.2V
- **Height (from base)** 37mm
- **Lighting** No

ELITE
NEW ENTRY
P66

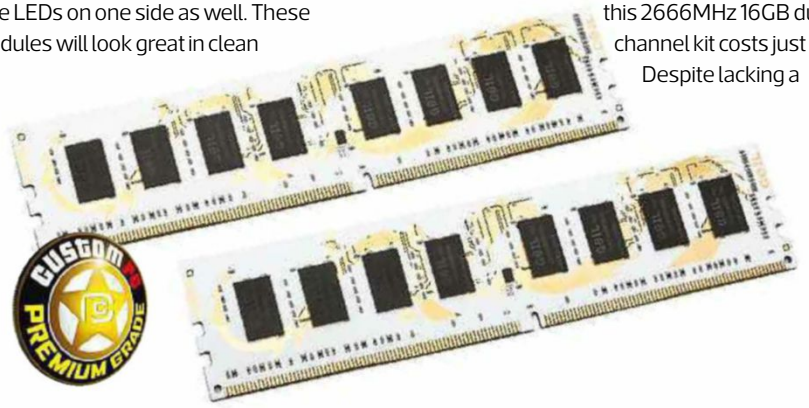
Geil Dragon RAM / £74 inc VAT

SUPPLIER www.comwales.co.uk / **MODEL NUMBER** GWB416GB2666C15DC

As the only memory kit without a heatspreader this month, you might expect Geil's Dragon RAM to be at a disadvantage. However, with a voltage of just 1.2V, the lack of a heatsink is unlikely to be an issue in terms of cooling either. What's more, to make the bare PCB look good, Geil has added a simply gorgeous colour scheme to the PCB instead.

With a white background and gold dragon design, the modules look fantastic, sporting blue LEDs on one side as well. These modules will look great in clean white cases, or installed in MSI's Krait or Titanium motherboards.

Despite the lack of a heatsink, the Dragon RAM could also overclock, climbing to 3100MHz with a voltage of 1.4V and stock timings of 15-17-17-36, although this result was the second lowest frequency on test. However, another aspect in the Dragon RAM's favour is its low profile – measuring just over 30mm tall, it's ideal for tight situations with large CPU coolers. Its price is another bonus – this 2666MHz 16GB dual-channel kit costs just £74.



Despite lacking a heatsink, the Geil Dragon RAM is still cool to the touch, even when overclocked. It might not overclock quite as high as the competition, but its low price, short profile and fantastic colour scheme enable it to offer a great balance for the money.

PERFORMANCE	DESIGN	VALUE
24/30	20/25	44/45

VERDICT

Affordable, great-looking and low-profile, the Geil Dragon RAM offers the best balance on test.

OVERALL SCORE 88%

/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 15-17-17-36
- **Voltage** 1.2V
- **Height (from base)** 30.5mm
- **Lighting** Single blue LED

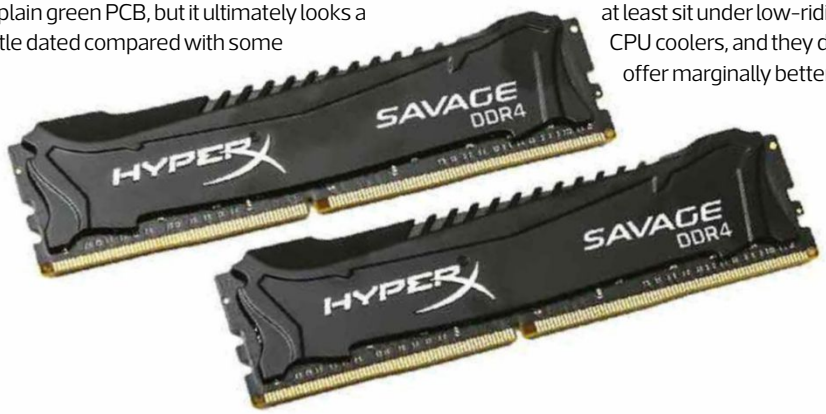
HyperX Savage Black / £80 inc VAT

SUPPLIER www.overclockers.co.uk / **MODEL NUMBER** HX426C13SB2K2/16

Memory maker Kingston is using its HyperX brand for all sorts of products now, from SSDs to headsets, but it still makes plenty of enthusiast memory kits too. The HyperX Savage Black features a pair of 8GB 2666MHz DIMMS, sporting some very tight timings indeed at just 13-15-15-31.

Aesthetically, the Savage Black modules look similar to Corsair's Vengeance LPX DIMMs, with plain black jagged heatsinks and a jagged shape. The design looks better than a plain green PCB, but it ultimately looks a little dated compared with some of the models coming from the competition now, some of which are cheaper and also feature lighting.

We also couldn't overclock the Savage modules very far, with them topping out at just 2900MHz – the lowest result on test. We suspected that the tight timings might be holding back our efforts, but even raising them to the same level as the Avexir Impact kit at 15-15-15-35 didn't see any improvement. On the plus side, the Savage modules are also fairly short, so they should at least sit under low-riding CPU coolers, and they did offer marginally better performance in one or two tests at stock speed thanks to the tight timings too.



These speed differences were tiny, though, and at this price, the HyperX Savage can't compete with the cheaper, more attractive and better overclocking kits.

PERFORMANCE	DESIGN	VALUE
22/30	16/25	36/45

VERDICT

A reasonable kit with super-tight timings, but they look bland and are limited overclockers.

OVERALL SCORE 74%

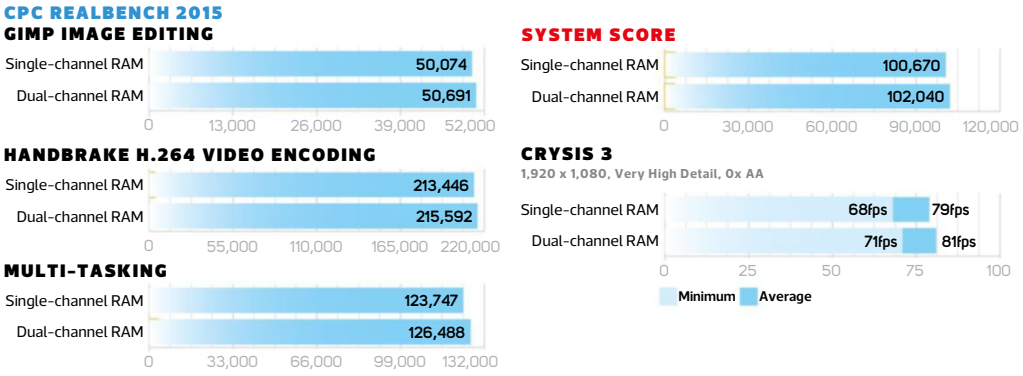
/SPECIFICATIONS

- **Frequency** 2666MHz
- **Timings** 13-15-15-31
- **Voltage** 1.35V
- **Height (from base)** 33.5mm
- **Lighting** No

Single-channel vs dual-channel memory

Intel's Skylake platform supports dual-channel memory, enabling two memory modules to interleave their bandwidth, theoretically making them faster than a single stick of the same capacity. But how important is dual-channel mode when memory is already running at such a high frequency? Could you save some money by buying a single stick without much of a performance hit?

To find out, we set a 16GB (2 x 8GB) kit and a single 16GB DIMM of the same type, with the same frequency and timings, and while the differences were small, they were definitely noticeable. Using our test system, which sported a GTX 1060 and Core i5-6600K, you see 3fps added to the Crysis 3 minimum frame rate in dual-channel mode – a boost of just under 5 per cent, and the dual-channel kit was 2 per cent quicker in our RealBench test system score too, with the multi-tasking test benefiting the most.



Frequency vs timings

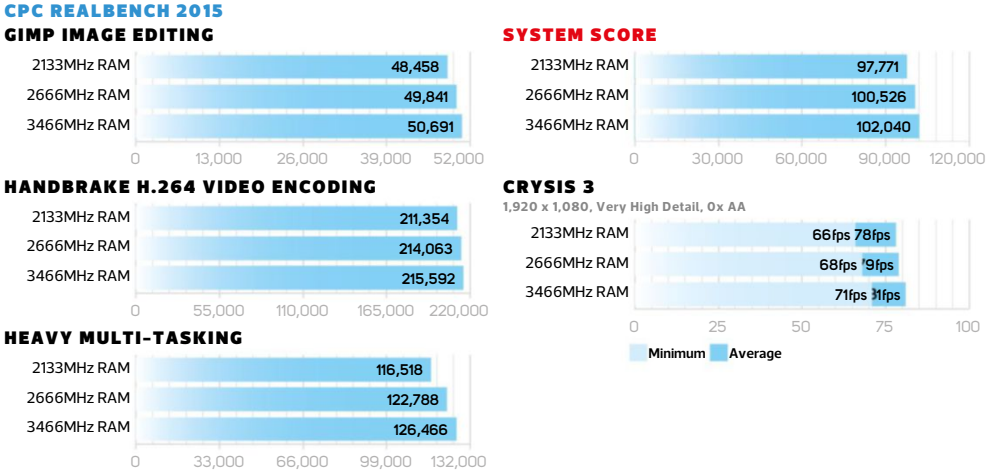
In addition to the clock frequency, your memory will also be set to certain latency timings, usually listed as a series of numbers, such as 13-15-15-31, which refer to the number of clock cycles needed for your memory to perform a whole operation. For example, the CAS (column address strobe) is the first figure in the series, and refers to the number of clock cycles that occur between your memory controller issuing a command to look up a particular column address, and that data then being output from the memory.

Latency timings do affect performance, but the differences you'll see among memory kits with similar frequencies aren't usually enough to warrant opting for one kit over another. For instance, there was very little difference in our benchmarks between the loosest and tightest timings in either of our frequency group tests this month. In fact, the difference in results was within the margin of error in some tests, and the tiny differences could also be down to slight differences in the CPU turbo-boost frequency in certain conditions.

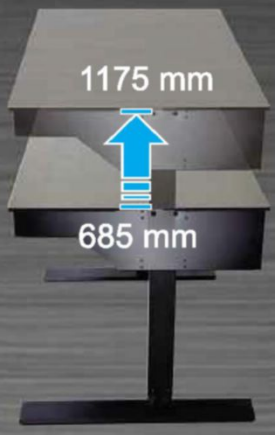
Frequency, on the other hand, can definitely improve performance, as you can see from the graphs below. However, you'll see diminishing returns as you move past 3,000MHz. In fact, as this month's Labs test shows, there are only small differences in performance as you move from 2666MHz up to 3200MHz.

Not surprisingly, the biggest differences appear when you compare a basic kit of 2133MHz RAM with memory set at this month's highest overclocked frequency. Moving from 2133MHz RAM to 3466MHz RAM, the system score in our RealBench suite rose from 97,771 to 102,040 – just over 4 per cent, while a substantial 5fps was added to the minimum frame rate in Crysis 3 – that's 8 per cent faster.

However, timings come into play when you're overclocking RAM too. In addition to increasing the voltage, loosening the timings can allow you to achieve higher frequencies, which will have a bigger impact on performance than the timings. By raising the timings one or two points, you may be able to boost your overclocks by several hundred MHz. As such, if you want to overclock your RAM, it pays to get a kit with low timings, as you may not have to loosen them as much to achieve a better overclock.



ELECTRICAL HEIGHT ADJUSTABLE TABLE



▲ **DK-04 X**

Dim.: (W)1200 mm x (H)685~1175 mm x (D)750 mm
Load on Tabletop: 100 kg (max)
Desktop Material: Tempered Glass
Body Material: Aluminum
Leg Material: Iron + Aluminum
Drive Bay: 5.25" x 1, 3.5" or 2.5" x 8, 2.5" x 2
Expansion Slots: x 8
Motherboard Type: E-ATX / ATX / Micro-ATX
System Fans (Front): 120 mm x 4
(Rear): 120 mm x 4
I/O Ports: USB3.0 x 4 / HD Audio
RGB LED Dimmer: x 1

▲ **DK-12 X**

Dim.: (W)1400 mm x (H)695~1185 mm x (D)750 mm
Load on Tabletop: 120 kg (max)
Body Material: Particle Board
Leg Material: Iron + Aluminum

DK-16 X

Dim.: (W)2100 mm x (H)695~1185 mm x (D)800 mm
Load on Tabletop: 80 kg (max)
Body Material: Particle Board
Leg Material: Iron + Aluminum

▲ PC-Y6 W 2016 SPECIAL EDITION

Distributor
OVERCLOCKERS UK

lianlihq | Lian Li HQ | www.lian-li.com Welcome OEM / ODM Project

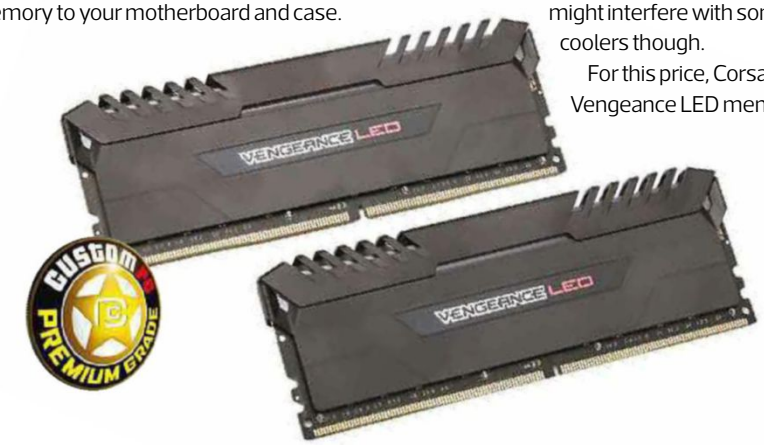
Corsair Vengeance LED / £89 inc VAT

SUPPLIER www.scan.co.uk / **MODEL NUMBER** CMU16GX4M2C3000C15R

If you're gunning for maximum visual pizzazz then Corsair's new Vengeance LED kits are as swanky as you can get. They sport a glowing, pulsating light bar at either end that looks great, although it's currently only available in red or white and there's no way to control the lighting. Knowing Corsair, though, an RGB version may arrive at some point, which would be handy for colour-matching your memory to your motherboard and case.

Despite sporting full lighting, though, the Vengeance LED doesn't cost a small fortune. This 3000MHz kit costs just £89, saving you £40 over the 2666MHz Avexir Impact kit (see p51). We were unable to get a 3200MHz kit from Corsair to test in this category, but this 3000MHz kit was able to reach 3466MHz without raising the timings anyway, equalling the best results on test. Measuring just 49mm tall, there's a good chance these modules might interfere with some air coolers though.

For this price, Corsair's Vengeance LED memory is an excellent buy, and the 3000MHz kit is a particularly sweet spot, costing just a couple of quid more than the 2666MHz version but able to overclock beyond the 3200MHz version once overclocked, which will cost you around £6 more.



PERFORMANCE	DESIGN	VALUE
29/30	21/25	40/45

VERDICT

With LEDs, a great price and solid overclocking performance, this is our favourite sub-£100 kit.

OVERALL SCORE 90%

/SPECIFICATIONS

- **Frequency** 3000MHz
- **Timings** 15-17-17-35
- **Voltage** 1.35V
- **Height (from base)** 49mm
- **Lighting** Red or white LED

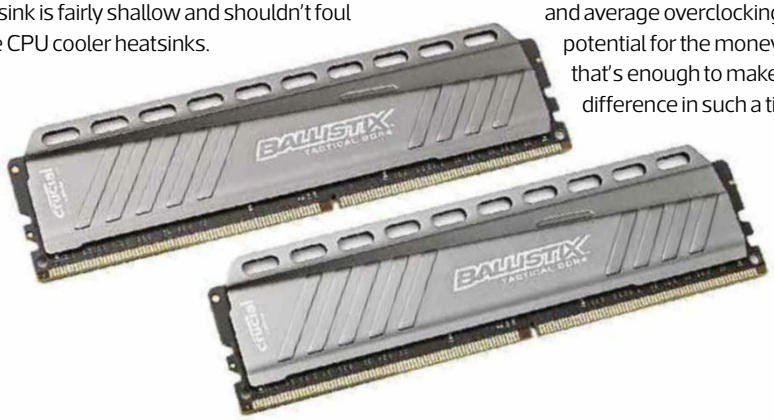
Crucial Ballistix Tactical / £85 inc VAT

SUPPLIER www.ebuyer.com / **MODEL NUMBER** BLT2C8G4D30AETA

As one of Crucial's fastest RAM kits, the Ballistix Tactical enters with all guns blazing and, at £85 inc VAT, it undercuts the Corsair, Team Group and G.Skill Trident Z kits too. It has an identical physical design to the 2666MHz kit we reviewed on p52, so it isn't particularly flashy – it has a comparatively bland, but smart-looking grey metallic heatsink. There's no lighting and there are definitely more attractive heatsinks too although, with a height of just 37mm, the heatsink is fairly shallow and shouldn't foul large CPU cooler heatsinks.

The latency timings are tight for a 3000MHz kit too, which gave it a marginal advantage in some tests. Sadly, though, we could only coax an additional 200MHz out of this kit when overclocking using the standard timings and raising the DDR voltage to 1.4V. This result is some way behind most of the other kits on test, and even three of the 2666MHz kits managed to get this far.

There isn't much wrong with the Ballistix Tactical other than a dated-looking heatsink and average overclocking potential for the money, but that's enough to make a difference in such a tightly competitive market. In its favour, the Tactical has a low-profile heatsink and includes a lifetime warranty too. However, there are better-looking and more competitively priced kits available that ultimately steal points from this Crucial kit.



PERFORMANCE	DESIGN	VALUE
28/30	16/25	36/45

VERDICT

Tight timings and a low profile, but overclocking and aesthetics are uncompetitive.

OVERALL SCORE 80%

/SPECIFICATIONS

- **Frequency** 3000MHz
- **Timings** 15-16-16-35
- **Voltage** 1.35V
- **Height (from base)** 49mm
- **Lighting** No

ELITE
NEW ENTRY
P66

G.Skill Trident Z / £93 inc VAT

SUPPLIER www.novatech.co.uk / **MODEL NUMBER** F4-3200C16D-16GTZB

There's no lighting available on G.Skill's Trident Z memory kits, but they still look great, thanks to a two-tone heatsink finished in dark grey and black brushed aluminium, with some red detailing. Our particular kit is rated at 3200MHz, so it's one of the faster kits here, although its timings were fairly loose at 16-18-18-38, which left it a percentage point behind the competition in our benchmarks – not a tragedy, but it may put off benchmarkers.

At £93 inc VAT, it's also a tad pricey for a non-LED kit, especially in a cutthroat market where mere pounds separate memory kits. As a result, there are a number of similar, better-looking kits available, including Corsair's Vengeance LED, which retail for similar prices. If you're not fussed about lighting, though, the Trident Z becomes better value for money – we managed to push our kit up to 3466MHz, leaving the timings where they where and raising the voltage to 1.4V – a good result. However, the modules' height of 44mm could make compatibility an issue with some CPU coolers.

The G.Skill Trident Z is a great-looking memory kit that overclocks well and will look great installed in any motherboard. However, it's let down by its price, which sees cheaper kits offering LED lighting and similar specifications undercutting it. If you're taken by those snazzy heatsinks, though, this is still a decent memory kit.

PERFORMANCE	DESIGN	VALUE
28/30	20/25	34/45

VERDICT

Pricey for a non-LED memory kit, but the modules overclock well and look great.

OVERALL SCORE 82%

/SPECIFICATIONS

- **Frequency** 3200MHz
- **Timings** 16-18-18-38
- **Voltage** 1.35V
- **Height (from base)** 49mm
- **Lighting** No

Geil Dragon RAM / £84 inc VAT

SUPPLIER www.watercoolinguk.co.uk / **MODEL NUMBER** GWW416GB3200C15DC

Having picked up an award for its 2666MHz kit this month, Geil is also offering a competitive price of just £84 inc VAT for the 3200MHz Dragon RAM, with just Patriot's Viper kit costing less money in this category. However, there's plenty of competition in the immediate vicinity, so it will still have its work cut out.

There's also one key difference, apart from timings and frequency, between the 2666MHz and 3200MHz kits, which is that Geil has also coloured the memory chips on the latter. They're white on the 3200MHz kit, which makes the modules look even better, along with the PCB's same satin-white finish, plus the golden dragon and subtle blue LED.

The timings are quite tight for a 3200MHz kit at 15-17-17-35, but we still managed to boost the frequency to 3466MHz without tweaking them, using a DDR voltage of 1.4V, which bodes well for further overclocking. There's no heatsink, although even stress testing at this frequency didn't see the modules become any hotter than lukewarm. The benefit of no heatsink, of course, is that the modules also have a super low profile too – with a height of just 30.5mm, they'll comfortably sit under any heatsink.

Geil's 3200MHz Dragon RAM doesn't beat Corsair's Vengeance LED kit aesthetically, but it's a great buy if you like its looks or need low-profile DIMMs, plus it's a good overclocker.

PERFORMANCE	DESIGN	VALUE
29/30	20/25	37/45

VERDICT

A very fair price, decent overclocking headroom and dashing good looks – a great deal.

OVERALL SCORE 86%

/SPECIFICATIONS

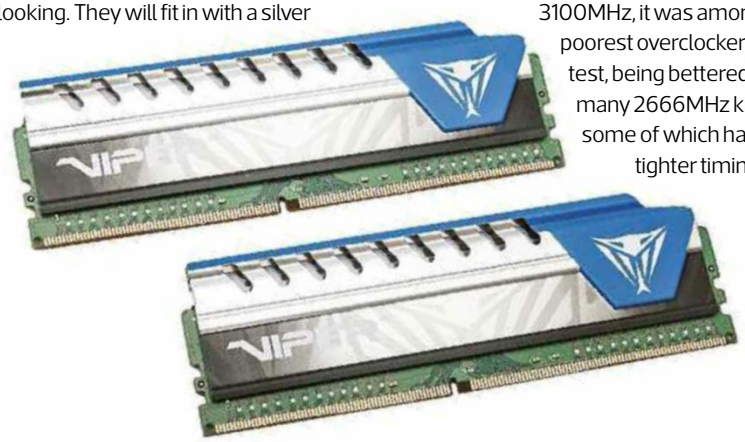
- **Frequency** 3200MHz
- **Timings** 15-17-17-35
- **Voltage** 1.35V
- **Height (from base)** 30.5mm
- **Lighting** Single blue LED

Patriot Viper Elite Series / £72 inc VAT

SUPPLIER www.amazon.co.uk / **MODEL NUMBER** PVE416G300C6KBL

If you're looking for a cheap 3000MHz 16GB dual-channel memory kit, then Patriot's Viper hits the mark, being even cheaper than any of the slower 2666MHz kits on test this month too. However, there are a number of shortcomings, even if it initially looks like a bargain. First off, is the decidedly bland and dated design – even the heatsink-less Geil DIMMs we reviewed this month are much better looking. They will fit in with a silver colour scheme, but you can get more pizzazz for not much more money elsewhere.

The Viper Elite's timings of 16-16-16-36 are reasonably tight, potentially providing some more headroom for extreme overclockers if you loosen them up a bit. Sadly, however, raising the DDR voltage to 1.4V and leaving the timings at their defaults meant we were only able to coax another 100MHz out of the Viper Elite – with a top frequency of 3100MHz, it was among the poorest overclockers on test, being bettered by many 2666MHz kits, some of which had even tighter timings too.



The Patriot Viper Elite offers reasonable performance at its stock settings, as well as a tempting price, but several slower kits beat it in the overclocking arena and its design is also a little bland. It's not a bad kit, but you'll get more perks by spending just a few more quid.

PERFORMANCE	DESIGN	VALUE
28/30	17/25	36/45

VERDICT

A good price, but there are more attractive kits available that also overclock higher.

OVERALL SCORE 81%

/SPECIFICATIONS

- **Frequency** 3000MHz
- **Timings** 16-16-16-36
- **Voltage** 1.35V
- **Height (from base)** 42mm
- **Lighting** No

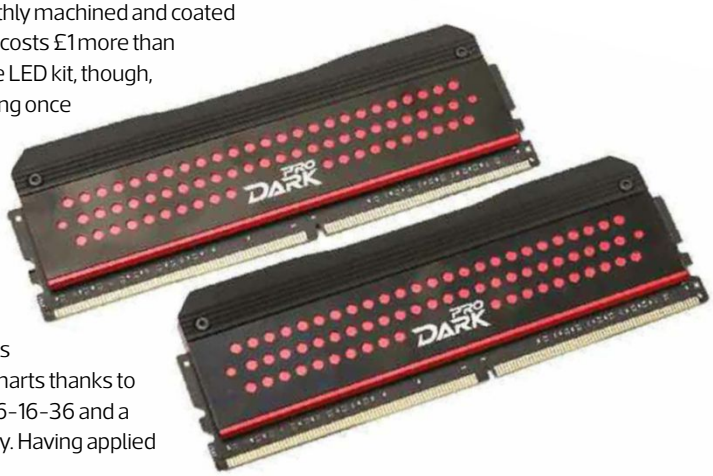
Team Group Dark Pro / £90 inc VAT

SUPPLIER www.overclockers.co.uk / **MODEL NUMBER** TDPRD416G3200HC16ADC01

The Team Group Dark Pro memory kit might not have LEDs, but its chunky, multi-layered heatsinks are well made and look fantastic, with no unsightly joins across the top. Two red sections of aluminium sit on the memory chips themselves, sandwiched between two metal plates with hexagonal perforations and all these parts held together by a large top section that's smoothly machined and coated matte black. This kit costs £1 more than Corsair's Vengeance LED kit, though, which is better looking once illuminated.

Most kits performed the same in our benchmarks, but there were some small differences and the Dark Pro was near the top of the charts thanks to tight timings of 16-16-16-36 and a 3200MHz frequency. Having applied a voltage of 1.4V and increasing the memory frequency, we reached 3333MHz – a seemingly average overclock given the stock frequency and that some kits managed to rise by much larger amounts, but it's the second fastest result on test nonetheless.

The Dark Pro's design is very appealing, making it worth considering if LED lighting is a bit over the top for your tastes. It's not cheap, but you get great stock performance, reasonable overclocking potential and a good-looking heatsink for £90, making it one of the better-rounded kits on test overall. It also comes with a lifetime guarantee from Overclockers UK.



PERFORMANCE	DESIGN	VALUE
28/30	21/25	36/45

VERDICT

Attractive heatsinks and fast speed make this kit a good choice if LEDs aren't to your tastes.

OVERALL SCORE 85%

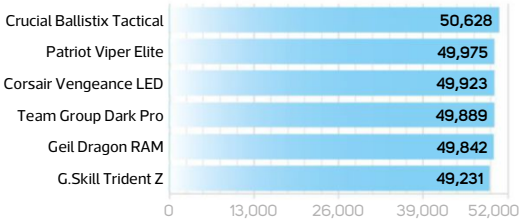
/SPECIFICATIONS

- **Frequency** 3200MHz
- **Timings** 16-16-16-36
- **Voltage** 1.35V
- **Height (from base)** 44.5mm
- **Lighting** No

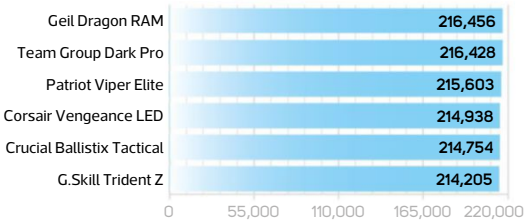
3000MHZ+ DDR4 MEMORY

CPC REALBENCH 2015

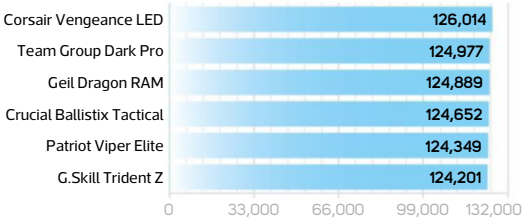
GIMP IMAGE EDITING



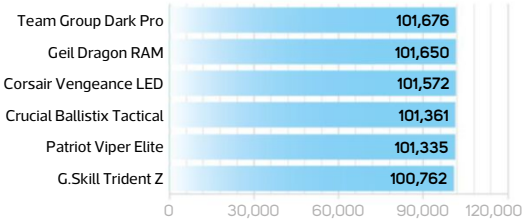
HANDBRAKE H.264 VIDEO ENCODING



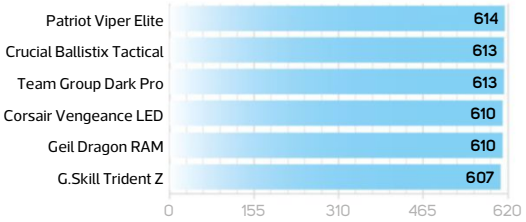
HEAVY MULTI-TASKING



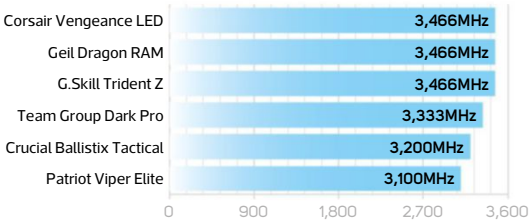
SYSTEM SCORE



CINEBENCH R15

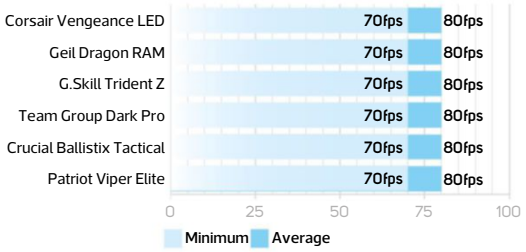


MAXIMUM OVERCLOCK FREQUENCY



CRYSIS 3

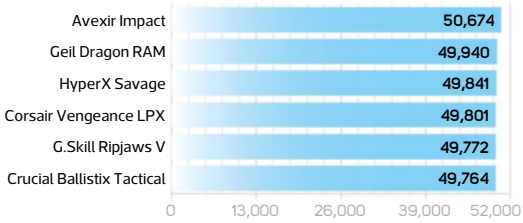
1,920 x 1,080, Very High Settings, 0x AA



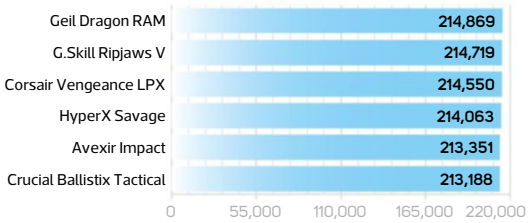
2666MHZ DDR4 MEMORY

CPC REALBENCH 2015

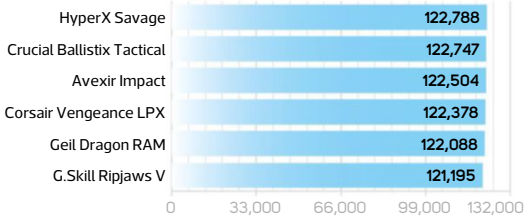
GIMP IMAGE EDITING



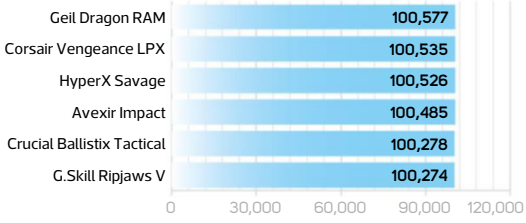
HANDBRAKE H.264 VIDEO ENCODING



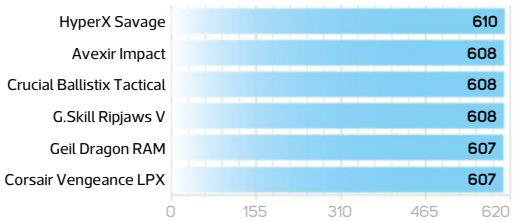
HEAVY MULTI-TASKING



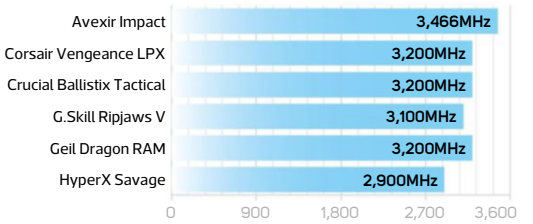
SYSTEM SCORE



CINEBENCH R15

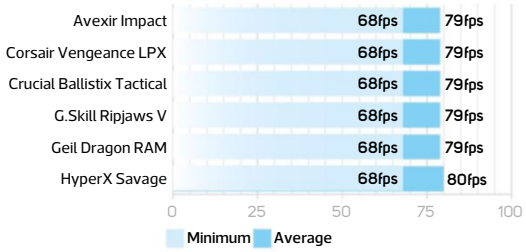


MAXIMUM OVERCLOCK FREQUENCY



CRYSIS 3

1,920 x 1,080, Very High Settings, 0x AA



PC system reviews

GAMING PC

CyberPower Hyper Liquid 100 / £1,999 inc VAT

SUPPLIER www.cyberpowersystem.co.uk

We'd usually point towards the components when a machine arrives with new, high-end gear inside, but the CyberPower Hyper Liquid 100 has a disarmingly distracting cooling system. It's a custom CPU cooling loop, and it's filled with neon green coolant. The bright liquid flows into the see-through Phobya UC-2 CPU waterblock, then to an Alphacool NexXxos ST30 240mm radiator hidden in the NZXT Manta's roof. The Alphacool Coolplex Pro reservoir decorates the front of the case, with the Phobya pump positioned beneath the PSU shroud.

It's an impressive amount of cooling hardware to fit inside a mini-ITX case, even if the Manta is larger than your average mini-ITX chassis. CyberPower has used the white version of the case, making its subtly curved side panels stand out. It's sturdy, and CyberPower has matched the green coolant with green-ringed LEDs to make the theme consistent.

The Hyper Liquid 100 is tidy too. Cables at the front are tucked away neatly or hidden beneath a raised, covered area in the middle of the Manta, bringing the water-cooling system to the fore, making for a great view through the side window.

CyberPower's PC only has a couple of minor problems. It isn't too neat around the rear, with cables loosely held together – the rear section just doesn't look as slick as Scan's regimented 3XS Z170 Nanu Vengeance Fluid (see Issue 157, p62), which was also built into a Manta case. As ever for a mini-ITX build, there's very little upgrade room too, with only a couple of awkward 2.5in mounts at the front available.

This machine holds a formidable amount of hardware already though. The Core i7-6700K has been overclocked from 4GHz to 4.4GHz, and it runs alongside 16GB of 3000MHz memory. CyberPower has also installed an Nvidia Founders Edition GTX 1080 card running at stock speed, with the core at 1607MHz and memory at 10GHz (effective). As with the Chillblast Fusion Platinum (see p62), though, it's a shame the GPU isn't water-cooled and overclocked as well as the CPU.

Scan's 3XS Z170 Nanu Vengeance Fluid is significantly more expensive than the CyberPower, but it has more power in several areas. There's an extra 200MHz of CPU speed as well as a GPU overclock, and the Scan's 512GB SSD is twice as large as the CyberPower's boot drive too.

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.4GHz

Motherboard Gigabyte Z170N-WIFI

Memory 16GB Corsair Vengeance LPX 3200MHz DDR4

Graphics Nvidia GeForce GTX 1080 8GB

Storage 256GB Samsung SM951 M.2 SSD; 2TB Seagate Barracuda hard disk

Case NZXT Manta White

Cooling CPU: Alphacool NexXxos ST30 240mm radiator with 2 x 120mm fans, Alphacool Coolplex Pro 15 LT reservoir, Phobya UC-2 waterblock, Phobya DC12-260 pump; GPU: 1 x 70mm fan; top: 2 x 120mm fans; rear: 1 x 120mm fan

PSU Corsair CX600M

Ports Front: 2 x USB 3, 2 x audio; rear 4 x USB 3, 1 x USB 3.1 Type-C, 1 x PS/2, 2 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Microsoft Windows 10 Home 64-bit

Warranty Two years parts and labour return to base, with first month collect and return, followed by one year labour only

There's very little to choose between the two PCs' motherboards though. The Gigabyte Z170N-WIFI inside the CyberPower has dual-band 802.11ac Wi-Fi, dedicated audio circuitry, USB 3.1 Type-C and no free slots. Scan's machine has many of the same features, even if its Asus board looks a little more outlandish. Both boards also have M.2 slots, and are inaccessible behind the motherboard tray.

There's barely any breathing room between the PSUs either. Both machines have modular Corsair CX-branded units with 80 Plus Bronze ratings, and the CyberPower's 600W PSU offers 50W more power than the Scan's box.

The two machines also have three year warranties, although Scan's is slightly better. The CyberPower offers three years of labour coverage and two years of parts protection, but Scan provides three years of parts and labour coverage, with the first year on site.

Performance

The CyberPower's GTX 1080 never dropped below 87fps at 1080p, and it managed at least 56fps in every 2,560 x 1,440 benchmark. It performed respectably at 4K too. Its best result was a 45fps minimum in The Witcher 3, and its lowest minimum was 26fps in Fallout 4 – just over our marker for a playable game, and easily improved by dropping the detail from Ultra to High. Scan's machine was a tad quicker in games thanks to its GPU overclock though.

Meanwhile, the CyberPower's CPU overclock helped it to deliver a decent benchmark score of 142,132. That result shows it has enough power to handle virtually any work task without breaking a sweat, but it isn't quite as quick as the Scan, which used its extra 200MHz of processing power to score 147,947 in the same test. The CyberPower's NVMe

ELITE
NEW ENTRY
P66

1 **The neon green liquid flows into a see-through Phobya UC-2 waterblock**

2 **An Nvidia Founders Edition GeForce GTX 1080 card handles gaming duties**

3 **A 240mm Alphacool NexXxos ST30 radiator sits in the NZXT Manta's roof**

SSD is fast too, clocking up sequential read and write speeds of 2,000MB/sec and 1,315MB/sec respectively.

Noise is always a potential downside to having so much hardware inside such a small space, though, and here the CyberPower falls down a little. Its cooling gear churns out a noticeable low rumble at all times, whether idle or stress-tested. Thankfully, the noise never modulated nor become louder, but it's definitely noticeable; the Scan is quieter. Temperatures were always good though. The water-cooled CPU topped out with a delta T of 51°C, while the GPU peaked at 59°C, neither of which is cause for concern

Conclusion

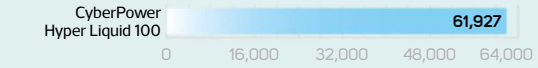
The overclocked Core i7 processor and stock-speed GTX 1080 deliver impressive power inside the CyberPower's modest chassis. The CPU has enough grunt for any home application or games, while the GTX 1080 can handle 2,560 x 1,440 gaming with ease, and it can even cope with some 4K gaming smoothly. The Hyper Liquid 100 pairs its good components with a bright, effective water-cooling system, and the rest of the build is neat and tidy too.

Scan's similar system is a little quicker in benchmarks, has a bigger SSD, is a tad quieter and has a more generous warranty. It's also much more expensive, and that's the main benefit of the CyberPower – it offers a very similar machine, with a few drawbacks, but a much cheaper price. If your budget is limited to £2,000, few mini PCs offer more power while looking quite so good.

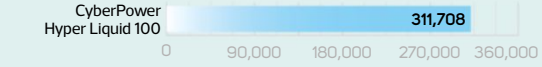
MIKE JENNINGS

CPC REALBENCH 2015

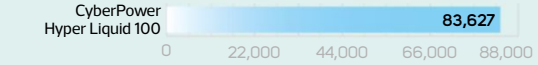
GIMP IMAGE EDITING



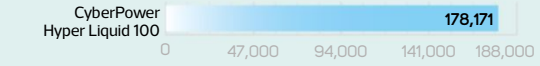
HANDBRAKE H.264 VIDEO ENCODING



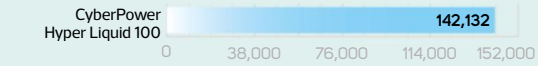
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 142.19%

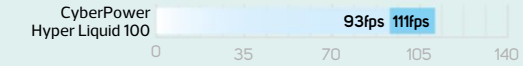
SPEED	DESIGN	OVERALL SCORE
22/25	22/25	90%
HARDWARE	**VALUE**	
23/25	23/25	

VERDICT

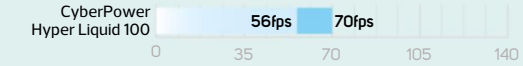
Loads of gaming power in a well-built system with a striking water-cooling system.

FALLOUT 4

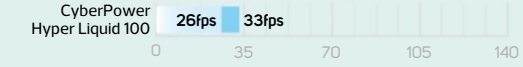
1,920 x 1,080, Ultra Detail, TAA



2,560 x 1,440, Ultra Detail, TAA

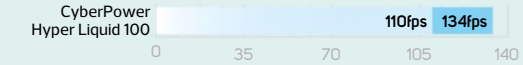


3,840 x 2,160, Ultra Detail, TAA

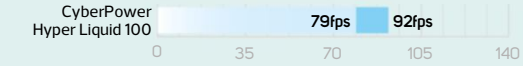


THE WITCHER 3: WILD HUNT

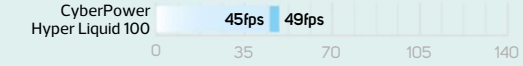
1,920 x 1,080, High Detail, AA on



2,560 x 1,440, High Detail, AA on



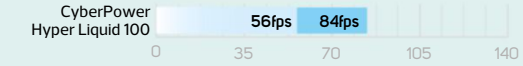
3,840 x 2,160, High Detail, AA on



CRYSIS 3

1,920 x 1,080, Very High Detail, 0x AA

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA

Minimum Average

GAMING PC

Chillblast Fusion Platinum / £2,700 inc VAT

SUPPLIER www.chillblast.co.uk

The Chillblast Fusion Platinum is one of the most outrageous PC's we've seen. Its Thermaltake Core P3 case is largely open to the air, with the components sandwiched between a sturdy steel backplate and a thick, clear acrylic façade. The water-cooling system takes pride of place in this rig, and behind the acrylic, its pipes and reservoir course with a coolant cocktail. Chillblast has used Mayhems Aurora 2 Silver in most of the loop, but the firm has put a little bit of Mayhems Black inside to darken it down, making the swirling effect even more dramatic.

A cylindrical reservoir sits on a bracket at the front of the case, with a 360mm radiator and three 120mm fans looming behind it. The entire water-cooling system is built using XSPC hardware, and it looks stunning in motion; shimmering coolant swirls around the reservoir like a lava lamp before coursing through the various tubes.

Chillblast's cooling system draws the gaze, but it isn't the only bit of eye-catching hardware. The Core P3 looks striking and sports a clutch of intriguing features. Chillblast builds the Fusion Platinum to stand vertically on two sturdy feet, but Thermaltake has designed the case so it can also lie horizontally or even be wall-mounted. That acrylic front panel is a boon too. It's easy to remove, and it makes building and tinkering far simpler due to the absence of side panels, although you'll need to keep an eye on dust building up in a PC, as there are no panels or dust filters.

The back panel slides away to reveal some upgrade room, too. There are three 2.5in bays around the back, alongside a spare 3.5in hard disk cage, and the motherboard has the usual pair of memory slots free, alongside various slots and headers. The machine is consistently tidy, with discreet black cables barely visible behind the cooling gear at the front, and well-routed wires at the rear.

Don't discount the components behind the shimmering fluid either. The GTX 1080 runs across the middle of the system, with its 2,560 stream processors and 8GB of lightning-fast GDDR5X RAM. Chillblast hasn't overclocked the GPU, but it still has its formidable 1607MHz base clock and 10GHz (effective) memory.

Given the extensive water-cooling system, though, it's a pity the GPU isn't water-cooled and overclocked too. Elsewhere, there's a Core i7-6700K overclocked to 4.6GHz and the usual 16GB of memory, which runs at 3000MHz. Meanwhile, storage comes from the familiar combination of a 512GB Samsung 950 Pro SSD and a 4TB hard disk.

The metallic look is complemented by the MSI Z170A XPOWER Titanium motherboard. The bright PCB is topped off by chunky metal heatsinks finished with a sand-blasted effect, and several of the PCI-E slots are ringed with metal to support hefty GPUs. The board serves up all the usual enthusiast features, with dedicated audio circuitry and numerous overclocking tools. There's a two-figure POST display in the top-right corner, and on-board buttons can be added with a tiny daughterboard that attaches to the bottom of the main PCB.

Meanwhile, expansion potential is boosted by a second M.2 slot below the graphics card, and the rear I/O panel has the familiar selection of USB 3.1 ports, PS/2 connectors and a clear-CMOS button.

The whole lot is powered by a 750W Corsair RMX PSU, which is a lengthy modular unit with an 80 Plus Gold rating – it's a decent power supply.

We don't have any qualms about the warranty either, which offers two years of parts and labour cover with a collect and return service, followed by a further three years of labour only cover with a return to base deal.

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.6GHz

Motherboard MSI Z170A XPOWER Gaming Titanium

Memory 16GB Corsair Vengeance LED 3000MHz DDR4

Graphics Nvidia GeForce GTX 1080 8GB

Storage 512GB Samsung 950 Pro M.2 SSD; 4TB Seagate hybrid hard disk

Case Thermaltake Core P3

Cooling CPU: XSPC RayStorm waterblock; XSPC D5 Photon 170 reservoir; XSPC D5 Vario pump; XSPC AX360 360mm radiator with 3 x 120mm fans; GPU: 1 x 70mm fan

PSU Corsair RM750X

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 3 x USB 2, 4 x USB 3, 2 x USB 3.1 Type-A, Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Microsoft Windows 10 Home 64-bit

Warranty Two years collect and return parts and labour, followed by three years return to base labour only

Performance

Even though the GPU isn't overclocked, the stock-speed GTX 1080 is a superb graphics card that will cruise through any current game at 1080p and 2,560 x 1,440 – it rattled through our toughest game test at the latter resolution with a minimum frame rate of 56fps. There's just about enough power to run games at 4K, too. Its lowest score at 4K came in Fallout 4, where it hit a playable minimum of 26fps, but it delivered an impressive 45fps minimum in The Witcher 3.

The overclocked Core i7 processor keeps pace with other recent machines too. The four overclocked and Hyper-Threaded cores helped it to achieve a decent Handbrake H.264 video encoding score, and the Fusion Platinum's overall result of 148,181 shows it has plenty of processing power available. The Samsung 950 Pro SSD delivered excellent read and write speeds of 2,194MB/sec and 1,387MB/sec, showing the benefit of an NVMe PCI-E 3 SSD.

1 **Chillblast has mixed Mayhems Aurora 2 Silver with a little bit of Mayhems Black**

2 **The Thermaltake Core P3 is designed so it can even be wall-mounted**

3 **All of the water-cooling components are manufactured by XSPC**

The temperature readings were good too. The water-cooled CPU delivered a delta T of 62˚C, which is absolutely fine for an overclocked processor, while the GTX 1080 was 3˚C cooler. The Fusion Platinum produced consistent noise levels during our tests too.

When idle, a low rumble was emitted by the trio of fans on the XSPC radiator, and the noise never became louder, even when running games and stress tests. That's a decent outcome considering this machine doesn't have side panels or sound-dampening features.

Conclusion

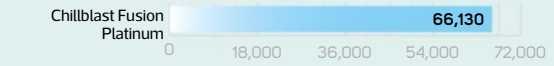
The Chillblast Fusion Platinum has an incredible design. The Thermaltake Core P3 is an outlandish case, and Chillblast has filled the gap between its metal and acrylic panels with an eye-catching, effective water-cooling system. If you're after a PC to draw admiring glances, the Fusion delivers the goods, although Chillblast has missed a trick by not water-cooling the GPU as well.

It's fast too, thanks to the GTX 1080 GPU, Core i7 processor and Samsung storage Of course, this level of performance can be achieved for hundreds of pounds less if you give up the extravagant build, but the Fusion Platinum is an excellent option if you want a fast, well-built PC that looks special while it blasts through 4K games.

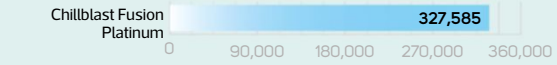
MIKE JENNINGS

CPC REALBENCH 2015

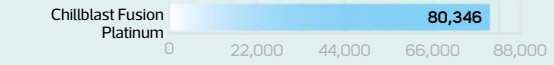
GIMP IMAGE EDITING



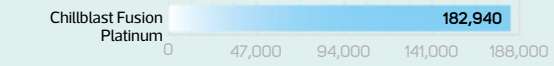
HANDBRAKE H.264 VIDEO ENCODING



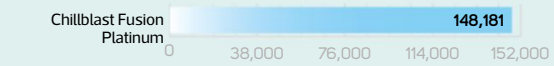
LUXMARK OPENCL



HEAVY MULTITASKING



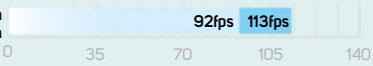
SYSTEM SCORE



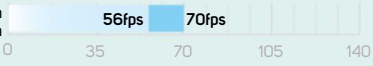
INTEL REFERENCE: 129.4%

FALLOUT 4

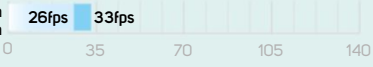
1,920 x 1,080, Ultra Detail, TAA



2,560 x 1,440, Ultra Detail, TAA

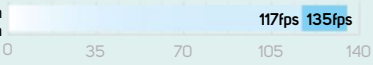


3,840 x 2,160, Ultra Detail, TAA

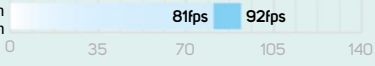


THE WITCHER 3: WILD HUNT

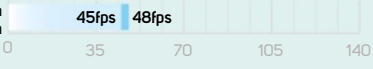
1,920 x 1,080, High Detail, AA on



2,560 x 1,440, High Detail, AA on

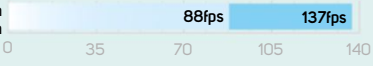


3,840 x 2,160, High Detail, AA on



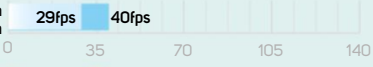
CRYSIS 3

1,920 x 1,080, Very High Detail, 0x AA



2,560 x 1,440, Very High Detail, 0x AA

3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

SPEED	DESIGN	OVERALL SCORE
22/25	24/25	90%
HARDWARE	VALUE	
24/25	20/25	

VERDICT

Incredible, bold design and good cooling combined with an effective set of components.

GAMING PC

Scan 3XS X99 Carbon X SLI / £4,500 inc VAT

SUPPLIER www.scan.co.uk

The Scan 3XS X99 Carbon X SLI marks the debut of Nvidia's new Nvidia GeForce Titan X (see p20), pairing two of these monster Pascal-powered cards in SLI configuration. The two cards produce fearsome specifications. There's 24GB of GDDR5X 10GHz (effective) memory between them, and the cards call on 7,168 stream processors and 24 billion transistors to destroy tough gaming workloads.

The clock speeds are incredible too. Scan has raised the Titan X's GPU stock speed of 1417MHz by 185MHz, meaning that the core clock is just a little short of that of the GTX 1080. The Founders Edition Titan X cards are also joined by Nvidia's new, smart-looking high-bandwidth SLI bridge.

The GPUs are the star performers, of course, but don't discount the rest of the specification. Intel's Core i7-6850K is a step above the chips usually seen in gaming systems. This Broadwell-E CPU has six Hyper-Threaded cores, and Scan has increased the clock speed from 3.6GHz to 4.2GHz as well. Importantly, the Core i7-6850K also offers the full 40 lanes of PCI-E 3 bandwidth without the unnecessary excess of 8-core and 10-core chips, meaning there's 16 lanes for each Titan X card.

Scan uses a Corsair Hydro H100i V2 to keep this beefy CPU's overclock in check. It sits comfortably in the roof with two 120mm fans, and the system is also serviced by a 140mm intake fan and a 120mm exhaust.

The LGA2011-v3 CPU sits in an Asus ROG Strix X99 Gaming motherboard, which features built-in Wi-Fi, high-end audio and reasonable upgrade room, although some ports and slots are tricky to reach. It also has on-board power and reset buttons, and a POST display, while the M.2 socket is accompanied by an arguably less useful U.2 port.

There's loads of lighting too. The motherboard heatsinks, mid-board ROG logo and roof-mounted LED strip are all connected to the Asus Aura system, which uses RGB LEDs to display any colour in a variety of effects. Those lights illuminate the Corsair Carbide 400C, which has black cabling alongside the dark, unfussy motherboard tray and PSU shroud. It's the usual tidy building job from Scan, and it puts components front and centre, all on display through a huge window.

The tidy cabling continues around the rear, and there's more expansion room behind the motherboard tray, with three 2.5in bays and a solitary 3.5in bay. The dark interior contrasts with the Carbide case's white exterior. The two-tone machine looks great, and build quality is rock-solid, thanks to the steel construction. The build is also augmented by easily removable dust filters and a hinged side panel.

Meanwhile, the 32GB of 2666MHz DDR4 memory is more than enough, and there's a 512GB Samsung 950 Pro NVMe SSD alongside a 2TB hard disk. Then there's the 850W Corsair RMX PSU, which has an 80Plus Gold rating and smart braided cables, and all this gear is protected by the usual Scan warranty, which is a three year parts and labour deal with a generous year of on site coverage.

Performance

The Titan X cards destroyed our 4K benchmarks. The Scan's lowest minimum was 51fps in The Witcher 3, and that was bolstered by an average of 110fps. Its minimums were even faster in other games: 73fps in Fallout 4 and 80fps in Crysis 3. Our standard benchmarks are demanding, but there's still room to go higher. Incredibly, the Scan barely broke a sweat with every graphics option tuned to the max at 4K.

The top Crysis test saw MSAA turned up and motion blur added, and the Carbon X still managed a 53fps minimum. It was even faster in Fallout 4, despite the added debris and ambient occlusion, returning a 64fps minimum. In The Witcher 3, the jump to Ultra settings added NPCs, increased texture quality, upped the visibility and activated Nvidia HairWorks. Despite all that, though, the Scan still never dropped below 39fps in this game.

These phenomenal results clearly indicate that this machine can handle any game at 4K with every option maximised, while also offering enough power for multi-monitor rigs and VR headsets.

The 6-core processor was no slouch either. Its overall score of 159,648 is around 10 per cent faster than most overclocked quad-core chips. A closer look reveals the pros and cons of this Extreme-edition CPU. Its image editing score of 48,926 is slower than most overclocked quad-core PCs, as that test is heavily dependent on single-core speed.

/ SPECIFICATIONS

CPU 3.6GHz Intel Core i7-6850K overclocked to 4.2GHz

Motherboard Asus ROG Strix X99 Gaming

Memory 32GB (4 x 8GB) Corsair Vengeance LPX 2666MHz DDR4

Graphics 2 x Nvidia GeForce Titan X 12GB

Storage 512GB Samsung 950 Pro M.2 SSD; 2TB Western Digital Blue hard disk

Case Corsair Carbide 400C White

Cooling CPU: Corsair Hydro H100i V2 with 2 x 120mm fans; GPU: 2 x 70mm fans; front: 1 x 140mm fan; rear: 1 x 120mm fan

PSU Corsair RMX850

Ports Front: 2 x USB 3, 2 x audio; rear: 4 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 4 x USB 2, 1 x PS/2, 1 x Gigabit Ethernet, 5 x audio

Operating system Microsoft Windows 10 Home 64-bit

Warranty Three years parts and labour, with one year on site and two years return to base

ELITE
NEW ENTRY
P66

1 **Most of this PC's budget has been spent on the pair of Nvidia Titan X cards**

2 **There's no custom water cooling, but the Corsair H100i V2 is still capable**

3 **The usual tidy build job from Scan puts components front and centre**

However, the extra cores helped the Scan to deliver huge improvements in the video encoding test. Intense workloads are clearly this machine's speciality. Meanwhile, the Samsung NVMe SSD's read and write speeds of 2,007MB/sec and 1,402MB/sec are blisteringly quick.

There were no noise or heat issues either. The Scan was admirably quiet when idle, and when stressed, its fans produced a whirr that wasn't much louder than other gaming systems – it's noticeable but not annoying. The Corsair H100i helped the overclocked CPU to return a chilly delta T of 42°C, while the GPU delta T peaked at just 59°C. That's high, but still fine, and par for the course when you put two beefy GPUs together.

Conclusion

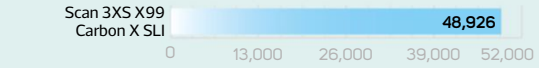
The inclusion of two Titan X GPUs means Scan's latest machine offers an unprecedented amount of gaming power, blasting through any game at 4K with every graphics setting turned up. Meanwhile, the 6-core CPU is really powerful in heavily multi-threaded tasks, such as video encoding. The rest of the specification is great, the build is solid and the system manages to be relatively quiet.

The only sticking point, really, is the price – in this league, we usually expect custom water cooling and fancy frills, but in this case the budget has gone on the graphics hardware. The Scan's price is huge, but so is the power on offer. If you want unfaltering 4K gaming performance, and are prepared to pay the price, then this is an incredible PC.

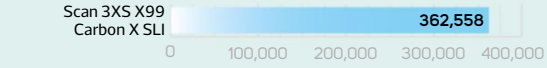
MIKE JENNINGS

CPC REALBENCH 2015

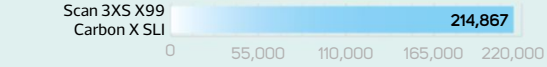
GIMP IMAGE EDITING



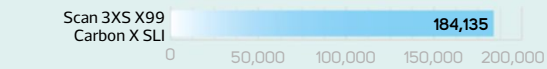
HANDBRAKE H.264 VIDEO ENCODING



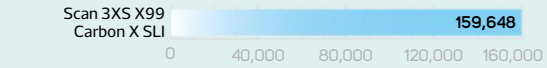
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE

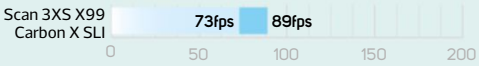


INTEL REFERENCE: 139.49%

FALLOUT 4

2,560 x 1,440, Ultra Detail, TAA

3,840 x 2,160, Ultra Detail, TAA



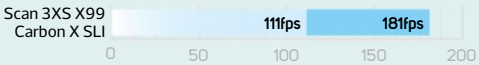
THE WITCHER 3: WILD HUNT

2,560 x 1,440, High Detail, AA on

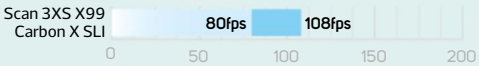
3,840 x 2,160, High Detail, AA on

CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

SPEED	DESIGN	OVERALL SCORE
25/25	22/25	87%
HARDWARE	**VALUE**	
24/25	16/25	

VERDICT

Monstrous dual-GPU power and excellence in every key department make for an exceptional, though very expensive, gaming PC.

Elite

Our choice of the best hardware available

Build a home theatre PC

The parts you'll need to build an affordable, home theatre PC that's ideal for putting in the lounge and playing back all manner of video formats. This machine will handle general computing and media tasks with no trouble, and its dual-core Skylake CPU can even handle 4K video playback. Meanwhile, its super-quiet Noctua CPU cooler prevents it from making a racket.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Lian Li PC-Q09FNB with 300W FSP SFX PSU	www.overclockers.co.uk	Issue 149, p92	£125
	Intel Core i3-6100T	www.overclockers.co.uk	Issue 149, p92	£102
	Asus H110i-Plus D3	www.scan.co.uk	Issue 149, p92	£68
	8GB Corsair 2133MHz Vengeance LP DDR3 (CML8GX3M2A2133C11B)	www.scan.co.uk	Issue 149, p92	£46
	Noctua L9i	www.scan.co.uk	Issue 149, p93	£32
	Samsung SN-208FB	www.overclockers.co.uk	Issue 149, p93	£17
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	Samsung 850 Evo 250GB	www.currys.co.uk	Issue 141, p51	£75
	Logitech K400 Plus	www.scan.co.uk	Issue 149, p93	£30
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87
			TOTAL	£643

Build a budget gaming PC

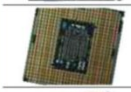
The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor, and even some games at 2,560 x 1,440. The machine has a discrete graphics card, a Skylake dual-core CPU and DDR4 memory. The ASRock Extreme4 motherboard is also capable of base clock overclocking via a BIOS update.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£65
	ASRock Z170 Extreme4	www.scan.co.uk	Issue 151, p84	£115
	Intel Core i3-6100	www.scan.co.uk	Issue 151, p18	£101
	8GB (2 x 4GB) Corsair Vengeance LPX 2400MHz (CMK8GX4M2A2400C16)	www.ebuyer.com	Issue 151, p83	£40
	Asus Strix Gaming Radeon RX470 4GB UPDATED	www.box.co.uk	Issue 158, p22	£187
	Samsung 850 Evo 250GB	www.currys.co.uk	Issue 141, p51	£75
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
	EVGA SuperNova GS 550W	www.cclonline.com	Issue 146, p50	£71
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87
			TOTAL	£828

Build a mid-range PC

Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, a fast M.2 SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	SilverStone Primera PM01	www.scan.co.uk	Issue 157, p25	£90
	Asus Maximus VIII Ranger	www.scan.co.uk	Issue 147, p44	£163
	Intel Core i5-6600K	www.overclockers.co.uk	Issue 145, p17	£216
	2666MHz Geil Dragon RAM (GWB416GB2666C15DC) UPDATED	www.comwales.co.uk	Issue 158, p53	£74
	NZXT Kraken X41	www.alza.co.uk	Issue 138, p57	£71
	EVGA SuperNova GS 550W	www.cclonline.com	Issue 146, p50	£71
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	Samsung SSD 950 Pro 256GB	www.shop.bt.com	Issue 149, p48	£161
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87
			TOTAL	£994

Gaming PC

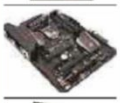
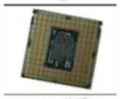
The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 and some 2,560 x 1,440 Asus Strix Gaming Radeon RX470 4GB UPDATED	www.box.co.uk	Issue 158, p22	£187
	2,560 x 1,440 Nvidia GeForce GTX 1060 6GB	www.scan.co.uk	Issue 157, p20	£240

Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory, a high-speed M.2 SSD and a proper liquid-cooling system.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Cooler Master Cosmos SE	www.scan.co.uk	Issue 144, p41	£115
	Asus Maximus VIII Hero	www.overclockers.co.uk	Issue 146, p20	£188
	Intel Core i7-6700K	www.scan.co.uk	Issue 145, p17	£308
	Corsair Vengeance LED (CMU16GX4M2C3000C15R) UPDATED	www.scan.co.uk	Issue 158, p56	£89
	Alphacool Eisbaer 240	www.aquatuning.co.uk	Issue 157, p28	£99
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£120
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	Samsung SSD 950 Pro 512GB	www.currys.co.uk	Issue 149, p48	£265
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87
			TOTAL	£1,332

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	2,560 x 1,440 Nvidia GeForce GTX 1060 6GB	www.scan.co.uk	Issue 157, p20	£240
	2,560 x 1,440 and some 4K Asus Strix GeForce GTX 1070 OC	www.scan.co.uk	Issue 156, p24	£491
	Smooth 4K Nvidia Titan X UPDATED	www.nvidia.co.uk	Issue 158, p20	£1,099

Build a high-end 6-core PC

Multi-threaded PC

The parts you'll need to build a PC with serious power in multi-threaded software, such as 3D rendering apps, video editing programs and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and top-end cooler listed. Also supplied is 16GB of RAM, a super-fast M.2 SSD, 1TB of extra solid state storage and Asus' superb X99 Deluxe II motherboard.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£138
	Asus X99 Deluxe II	www.scan.co.uk	Issue 156, p43	£371
	Intel Core i7-6850K	www.overclockers.co.uk	Issue 156, p26	£550
	Asus Strix Gaming Radeon RX470 UPDATED	www.box.co.uk	Issue 158, p22	£187
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16)	www.scan.co.uk	Issue 136, p14	£89
	EKWB EK-Predator 240 Rev 1.1	www.scan.co.uk	Issue 148, p30	£183
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£120
	Samsung SSD 950 Pro 512GB	www.currys.co.uk	Issue 149, p48	£265
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£263
	Lite-On IHAS124-14	www.shop.bt.com	Issue 99, p108	£10
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87
			TOTAL	£2,263

4K gaming PC

Replace the Asus RX470 graphics card with another graphics card to enable 4K gaming on this system, or take advantage of the Core i7-6850K's 40 PCI-E 3 lanes and add two GPUs for smoother frame rates.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	2,560 x 1,440 and some 4K Asus Strix GeForce GTX 1070 OC	www.scan.co.uk	Issue 156, p24	£491
	Smooth 4K gaming Nvidia Titan X UPDATED	www.nvidia.co.uk	Issue 158, p20	£1,099

Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a high-speed M.2 SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i7-6700K	www.scan.co.uk	Issue 147, p84	£308
	Corsair Vengeance LED UPDATED	www.scan.co.uk	Issue 158, p56	£89
	Corsair H80i	www.box.co.uk	Issue 147, p84	£87
	AMD RX480 8GB	www.overclockers.co.uk	Issue 156, p19	£240
	Samsung SSD 950 Pro 512GB	www.currys.co.uk	Issue 149, p48	£265
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	EVGA SuperNova GS 550W	www.cclonline.com	Issue 146, p50	£71
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£87

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Define Nano S	www.scan.co.uk	Issue 153, p22	£60
	Asus Z170i Pro Gaming	www.scan.co.uk	Issue 147, p26	£137
			TOTAL	£1,405

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 157, p53	£80
	Asus Maximus VIII Gene	www.overclockers.co.uk	Issue 147, p42	£185
			TOTAL	£1,473

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Budget ATX	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£65
	Sub-£100 performance	SilverStone Primera PM01	www.scan.co.uk	Issue 157, p24	£90
	Sub-£100 ATX quiet	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£100
	Sub-£150 full-sized ATX quiet	Nanoxia Deep Silence 5	www.quietpc.com	Issue 144, p50	£137
	Sub-£150 full-sized ATX	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£138
	Sub-£150 mid-size ATX	Cooler Master Cosmos SE	www.scan.co.uk	Issue 144, p41	£115
	Mini-ITX tower	Fractal Design Define Nano S	www.scan.co.uk	Issue 153, p22	£60
	Mini-ITX cube	Fractal Design Core 500	www.scan.co.uk	Issue 150, p20	£55
	Micro-ATX	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 157, p53	£80

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 gaming	Asus Strix Gaming Radeon RX470 4GB UPDATED	www.box.co.uk	Issue 158, p22	£187
	2,560 x 1,440 gaming	Nvidia GeForce GTX 1060 6GB	www.scan.co.uk	Issue 157, p20	£240
	2,560 x 1,440 and some 4K gaming	Asus Strix GeForce GTX 1070 OC	www.scan.co.uk	Issue 156, p24	£491
	Smooth 4K gaming	Nvidia Titan X UPDATED	www.nvidia.co.uk	Issue 158, p20	£1,099
	Mini-ITX	Asus GeForce GTX 970 DirectCU Mini	www.morecomputers.com	Issue 150, p38	£284

Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Mid-range 550W	EVGA SuperNova GS 550W	www.cclonline.com	Issue 146, p50	£71
	High-end 550W	Super Flower Leadex Platinum 550W	www.overclockers.co.uk	Issue 146, p52	£95
	Mid-range 750W	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£120
	High-end 1.2kW	Corsair Professional Series AX1200i	www.box.co.uk	Issue 111, p40	£289

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Router	Asus RT-AC68U	www.cclonline.com	Issue 128, p88	£149
	Wi-Fi adaptor	Asus PCE-AC68	www.cclonline.com	Issue 128, p88	£68

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Hard disk	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£61
	500GB SATA SSD	Samsung 850 Evo 500GB UPDATED	www.currys.co.uk	Issue 158, p44	£133
	1TB SATA SSD	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£263
	High-performance M.2 SSD	Samsung SSD 950 Pro 512GB	www.currys.co.uk	Issue 149, p48	£265
	NAS box	Synology DS216j	www.scan.co.uk	Issue 154, p28	£131

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	24in monitor	Dell U2414H	www.scan.co.uk	Issue 129, p43	£197
	27in 2,560 x 1,440 FreeSync monitor	Acer XF270HU	www.overclockers.co.uk	Issue 155, p46	£400
	27in 2,560 x 1,440 G-Sync monitor	Asus ROG Swift PG279Q	www.scan.co.uk	Issue 155, p48	£699
	27in 4K G-Sync monitor	ViewSonic XG2700-4K	www.amazon.co.uk	Issue 157, p26	£480
	27in 4K FreeSync monitor	Dell UltraSharp UP2715K	www.scan.co.uk	Issue 151, p44	£755
	34in ultra-wide curved G-Sync monitor	Asus ROG Swift PG348Q	www.cclonline.com	Issue 157, p42	£999

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Mechanical gaming keyboard	Cooler Master MasterKeys Pro S (Pro L version recommended if you need a numeric keypad)	www.box.co.uk	Issue 152, p44	£100
	Premium mechanical gaming keyboard	Corsair Gaming K70 RGB Rapidfire	www.box.co.uk	Issue 154, p21	£149
	Budget gaming mouse	Cooler Master Xornet II	www.box.co.uk	Issue 149, p28	£19
	Gaming mouse	Logitech G402 Hyperion Fury	www.scan.co.uk	Issue 139, p53	£50
	Ambidextrous gaming mouse	Roccat Kova	www.box.co.uk	Issue 150, p28	£50
	MMO gaming mouse	Corsair Scimitar RGB	www.box.co.uk	Issue 150, p17	£60
	Wireless gaming mouse	SteelSeries Sensei Wireless	www.box.co.uk	Issue 139, p61	£106

Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	PCI-E sound card	Asus Strix Raid DLX	www.scan.co.uk	Issue 148, p28	£162
	2.1 speakers	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£125
	Soundbar	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£190
	Headset	HyperX Cloud II	www.scan.co.uk	Issue 142, p46	£66
	Surround-sound headset	Asus Strix 7.1	www.shop.bt.com	Issue 142, p43	£149

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Quiet gaming PC	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 151, p60	c.£1,500
	Dream PC	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	Sub-£2,000 gaming PC	Scan 3XS Z170 Vengeance 1080 GL	www.scan.co.uk	Issue 155, p62	c.£1,950
	Mini-ITX gaming PC	CyberPower Hyper Liquid 100 UPDATED	www.cyberpower system.co.uk	Issue 158, p60	£1,999
	Premium mini-ITX PC	Overclockers 8Pack Asteroid	www.overclockers.co.uk	Issue 154, p56	c.£3,990
	Premium PC	Scan 3XS X99 Carbon Fluid GL SLI	www.scan.co.uk	Issue 156, p64	c.£4,100
	Water-cooled PC	Overclockers Infin8 Toxicity	www.overclockers.co.uk	Issue 150, p58	c.£3,414
	4K gaming PC	Scan 3XS X99 Carbon X SLI UPDATED	www.scan.co.uk	Issue 158, p64	£4,500
	Gaming laptop	CyberPower Fangbook 4 SK-X17	www.cyberpowersystem.co.uk	Issue 152, p30	c.£1,909
	Thin and light gaming laptop	Scan 3XS LG15 Vengeance G-Sync	www.scan.co.uk	Issue 153, p51	c.£1,480

Games

Contents

Inverse look p77 / No Man's Sky p78 / Abzû p80 / Inside p80 / Quadrilateral Cowboy p82 / The engine room – Snowdrop (The Division) p84

RICK LANE / INVERSE LOOK

NO MAN'S BUY

Questions over No Man's Sky's multiplayer mode lead Rick Lane to ask whether buyers have been misled

No Man's Sky is out. The game that lets you explore and land on a universe of colourful planets, which I've been wanting for approximately my entire life, was released last August. You can read my overall opinion of it over the page, but there's a particular issue with the game I want to tackle here.

Aside from the incredible procedural generation, perhaps the most talked-about aspect of No Man's Sky prior to release was the nature of its multiplayer. All players explore the same universe, and any discoveries players make are shared among everyone. However, the extent to which this universe is shared between players has led to a bit of controversy.

Until recently, many anticipants of No Man's Sky believed that players would be physically exploring the same universe and therefore would be able to cross each other's paths. The sheer size of No Man's Sky means the chances of this happening would be unlikely, but it would be possible nevertheless.

The game's creative director Sean Murray confirmed this on The Late Show with Stephen Colbert – when asked if players could see each other in game, he said, 'Yes, but the chances of that are incredibly rare because of the size of what we're building.'

Around the time of launch, however, this message changed. Hello Games instead emphasised that No Man's Sky is 'not a traditional multiplayer experience'. What's more, when two players did find themselves in the same location, it turned out they couldn't see each other at all. Hello Games claimed this situation may be a result of the overwhelming strain on its servers, and added that there 'may' be more player interaction in the future. However, the controversy deepened further when a player discovered that the collector's edition of the game had blank stickers placed over the PEGI rating boxes, obscuring a box that clearly stated online multiplayer play was included.

> When two players did find themselves in the same location, they couldn't see each other at all

Hello Games has been cagey about specific features of No Man's Sky for most of its development. Whether this was down to a desire to surprise players, or simply a consequence of the chaotic nature of game development, is unknown. Nevertheless, the mixed messages have resulted in some players feeling disappointed and misled.

Hello Games probably didn't intend to create this confusion, but being so ambiguous when discussing a product is dangerous ground. In extreme cases, developers risk falling foul of the Misrepresentation Act of 1967, which sets out guidelines for fraudulent, negligent and innocent misrepresentation of products. If a consumer relies on information about a product when purchasing, which transpires to be wrong, they can claim compensation, relative to the nature of the misrepresentation.

Hello Games may fix the issue, or implement multiplayer properly later, but that wouldn't excuse the lack of clarity. Creative flexibility is vital for game development, and ideas that don't work or prove unfeasible should be discarded. However, it's important that developers are as transparent as possible about this process, especially when a developer sells a game on ideas that ultimately don't feature in the final product.

The gaming community is already rife with suspicion and wrongheaded theories about how game development works, and the best way to dispel those theories is simply to be upfront about how development is progressing. It may be disappointing for players to hear that a game won't include an exciting feature, but it's far more disappointing to discover this knowledge after purchasing it. CPC

Rick Lane is Custom PC's games editor. @Rick_Lane

No Man's Sky / **£40** inc VAT

DEVELOPER Hello Games / **PUBLISHER** Hello Games / **WEBSITE** www.no-mans-sky.com

Playing No Man's Sky for the first time happens in four phases: curiosity, wonder, frustration and acceptance. Hello Games' stupendously ambitious space simulator promised an explorable virtual galaxy of unprecedented scale and diversity – 18 quintillion systems, each with multiple planets and moons on which you could land and explore.

On this promise, the developer categorically delivers, and the results are worth the entrance fee alone. However, Sean Murray and his team have been comparatively cryptic on what players will actually be doing on those 18 quintillion planets. The answer proves to be a mishmash of activities that, while functional enough, fail to amount to an experience that equals the joy of watching a new world unfold before you. It's a challenging game to criticise, so let's break down our experience into the different stages.

The first stage, curiosity, occurs at the very beginning, while the player grapples for the first time with the medley of systems on offer. No Man's Sky commences with the player character awakening on a random planet in the far fringes of the galaxy, tasked with the loose goal of reaching the centre of this spiral of stars. There are a couple of other progress paths through the game, but they all comprise the thinnest of threads from which to hang your own, personalised adventures.

Before you head off on your space holidays, however, there's a more mundane task to accomplish – repairing your damaged ship. Through this initial sprinkling of structure, No Man's Sky teaches you the basics of mining for materials, repairing ship and exosuit components, crafting new components, and scanning flora and fauna in exchange for funds. Meanwhile, you can drink in the sights of your starting planet, which is different for everyone. It could be a dead, brown space rock, a verdant garden world, or anything in between.

Even if that initial world is an alien paradise, though, it's unlikely you'll be able to resist the allure of space forever, and it's at this point, when you've patched up your ship and the galaxy unfolds in front of you, that the wonder sets in. No Man's Sky offers seamless transitions from planetary surfaces to interstellar travel. Pointing your ship at a new planet and hitting your pulse engines, watching it grow in your canopy window before breaching the atmosphere is an experience unique to this game, and it's truly a marvel.

What's more, every planet holds the capacity to surprise and delight. A planet's clouds and atmosphere often conceal its true nature, and it's only once you've landed that you can fully comprehend the kind of world with which you're dealing. It could be a sumptuous forest-world teeming with life; a fiery primordial environment prowled by alien dinosaurs; a radioactive deathtrap where you can't

stand on the surface for more than a minute before being cooked from the inside out.

No Man's Sky encourages you to explore through its discovery system, where all sorts of objects from plants to planets can be scanned, renamed and uploaded to the game's servers in exchange for in-game cash. In addition, each planet is dotted with question marks that, on closer inspection, may reveal alien trading posts, mysterious ruins, abandoned colonies and a host of other points of interest.

Initially, it's all utterly gripping. After a few hours, however, that second phase of frustration begins to set in. While the variety of planets is astonishing, their contents are far more limited. It isn't long before the points of interest begin to repeat with depressing regularity. This repetition also brings some of No Man's Sky's other idiosyncrasies to the fore. For example, there's a strong emphasis on crafting and inventory management, neither of which are particularly enjoyable.

The objects you craft are housed entirely within your inventory, so you never really see the fruits of your labour, and the ridiculous limitations upon your inventory space means you constantly have to shuffle items around into boxes like a galactic postal worker. Indeed, the inventory is such a pain in the hyperdrive that finding a ship with more inventory space, or a new exosuit upgrade, becomes one of the most exciting discoveries in the game. Given the incredible sights that the game otherwise offers, that's a little sad.

Other elements of the game are enjoyable but undercooked. The ship controls are designed to be simple and safe, but they err too far on the side of caution. It's impossible to crash, for example. Flying above planetary surfaces is automated, and even if you run into a space station at full speed, you'll just bounce off it, removing the potential for some fantastic survival stories.

It's possible to die during combat; like the game's exploration component, this is colourful and spectacular, as well as surprisingly challenging. Again, however, it's a very simplistic point-and-shoot affair, and the battles lack any context. There's no explanation about why you're being attacked, or which factions own the duelling battlecruisers in front of you.

Speaking of factions, the game has three alien civilisations, with which you can trade and interact in little scripted vignettes. A neat mechanic of No Man's Sky is the requirement to learn alien languages by picking up words on your travels, which can then be used to decipher the needs and wants of the aliens you encounter. Again, though, they're fleeting interactions rather than actual missions – a quick exchange in dialogue that either rewards or punishes you.

The underlying issue with all the above systems is that they drift away from the exploration and discovery aspects of the game rather than reinforcing it. The emphasis should be on finding objects rather than crafting them, delving into alien ruins or the skeletons of ancient spaceships to retrieve new technologies or ship schematics. If No Man's Sky imbued its explorative aspects on a deeper level, it would be a brilliant game, rather than simply a good one.

Eventually, though, you accept No Man's Sky. It isn't a game about lingering around on planets, mining out rocks and building better ship components. It's about jetting off to that next pinprick in the sky, and seeing what wonders await there.

Momentum is the key to getting the most out of No Man's Sky. Stand still for too long and the game becomes a drudge. Keep on the move, however, and it becomes rather special.

RICK LANE

OVERALL SCORE
75%

/ VERDICT
No Man's Sky isn't the stone-cold classic we'd anticipated, but it's nevertheless a unique and often breathtaking experience.

Abzû / £15 inc VAT

DEVELOPER Giant Squid / **PUBLISHER** 505 Games / **WEBSITE** www.abzugame.com

Abzû is the spiritual successor to Journey, ThatGameCompany's PS3-exclusive indie hit, which saw wandering nomads exploring a vast and eerily beautiful sandy desert. Abzû was created by a former team member of ThatGameCompany, and offers a similar overall structure, with an emphasis on motifs such as mystery and wonder. Yet where Journey was subtle, Abzû is like being slapped in the face with a fish.

That's fitting, because the power and allure of marine life is the theme of this underwater adventure. You play a lone diver who awakes in a crystal-clear ocean, and the player must traverse the subaquatic environment and locate the ruins of a lost civilisation, accompanied by almost every sea creature you can imagine.

Even now, when visually spectacular games are a dime a dozen, we've never seen a game quite like Abzû. Its gloriously colourful environments are filled to bursting with virtual life. Shoals of fish surround the player, following their movements as they dive, roll and leap in and out of the water. Your nameless diver can hitch rides on the backs of sea turtles, dolphins and even orcas. In later levels, huge beasts such as blue whales and giant squid emerge from the gloom, and stranger creatures such as jellyfish and anglerfish float eerily in the player's wake.

OVERALL SCORE
80%

/ VERDICT
Abzû's aquatic adventure is a unique treat for the eyes and ears, although it's a little too mysterious for its own good.

Inside / £15 inc VAT

DEVELOPER Playdead / **PUBLISHER** Playdead / **WEBSITE** www.playdead.com/inside

Inside is a sequel to Limbo in all but name. It's a subdued yet gorgeous 2D platformer in which you play as a vulnerable little boy in a world where everything you encounter wants to kill vulnerable little boys. It uses its minimalist control scheme to craft some simple yet enjoyably brain-tickling puzzles. It's violent, sombre and darkly funny. It's also not as good as Limbo, although it does have a few standout moments.

Inside primarily offers a new art style and a new world to explore. The beginning deliberately evokes Playdead's first game, as the boy awakes alone in a darkened forest. This time, there's no giant spider lurking in the shadows. Instead, men in vans patrol the roads threading through the trees, heavily armed and accompanied by vicious black dogs.

Soon, though, the woodland gives way to farmland and eventually urban sprawl, while Inside switches Limbo's darkness for the muted hues of a cloudy dawn. The excellent visuals are crisp and beautiful, but also moody and subtle. The grim, grey environments are highlighted with carefully placed daubs of colour, while the lighting of the deliberately abstracted environments is uncannily lifelike. Meanwhile, the exceptional animation emphasises the mood and emotions of characters, with carefully infused physics that lend characters and objects weight and momentum.

The world Inside depicts has more substance than that of Limbo too, being less of a nightmare dreamscape and more a coherent dystopia. Much of the storytelling is inferred, but brutal authoritarianism, mind control and a disregard for humanity are evident from the start. These elements are also weaved into the game's puzzles. The boy can often take direct control of the slouched, shuffling non-player characters that populate the world, and making a mistake

OVERALL SCORE
62%

/ VERDICT
Like falling off a skyscraper roof, Inside has great and terrifying views, a lot of inertia and culminates in a sudden, messy stop.

The sights of Abzû are breathtaking. In less skilled hands, the results would be ostentatious, but Abzû has infused its adventure with the beats and rhythms of musical storytelling. The game is tightly bound to its orchestral score, and the movements of the sea creatures seem almost choreographed. The music swells as you're carried down speedy currents, accompanied by hundreds of fish. In quieter moments, the soundtrack eases off, letting you take your time to bask in the idyllic surroundings.

Interactively, the game is stripped back, being mostly about the joy of moving amid these wonderfully represented creatures. Abzû is one of the few games that doesn't need feedback loops or arbitrary reward systems to convey joy. That said, the story is too vague for its own good. The plot is mainly conveyed through imagery, such as hieroglyphics painted onto the walls of ruined buildings. It's attempting to be ambiguous, but there's too little to go on.

Abzû's most damaging flaw, though, is that the game's camera seems to have a mind of its own. Getting it to face in the right direction is often a fight, and the game frequently assumes control of the camera without making it obvious. It's not a deal breaker, but it's a distraction.

Nevertheless, we recommend taking a dip into Abzû's wonderful watery world. You won't come away with many answers, but when the credits roll, you'll be left with some remarkable gaming memories.

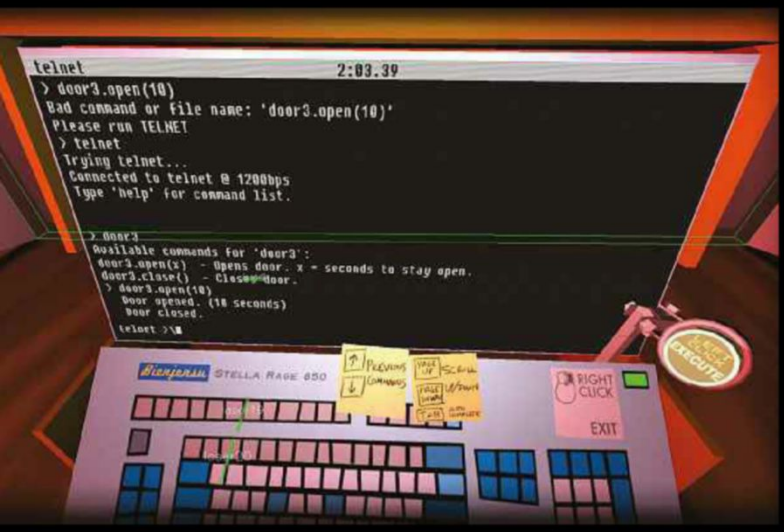
RICK LANE

while pushing an object or timing a jump will often result in an understated but equally horrifying death. Despite its child protagonist, Inside pulls no punches when depicting untimely ends.

However, it's difficult to escape the fact that Inside offers little that's new. Away from the mind control aspect, the puzzles are the same push-me, pull-you affairs, and where Limbo constantly escalated its drama, Inside seems to cruise on the same gear for a long while, introducing new ideas but then settling back into the same, slightly ponderous rhythm. Then, about half an hour from the end, the game swings completely the other way, with a truly bizarre ending, which comes seemingly out of nowhere and fails to conclude the game in a satisfying way.

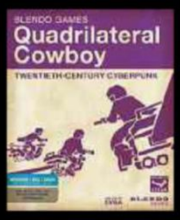
The ending prevents Inside from being a complete retread of familiar ground, but that isn't enough to elevate Inside to the same lofty heights as Limbo.

RICK LANE



Quadrilateral Cowboy / £15 incVAT

DEVELOPER Blendo Games / **PUBLISHER** Blendo Games / **WEBSITE** http://blendogames.com



Quadrilateral Cowboy is a new title from Thirty Flights of Loving developer Brendon Chung, which casts the player as an elite hacker in a retrofitted cyberpunk future where people ride hoverbikes and live in skyscrapers built from stacks of mobile homes.

The aim is to pull off a sequence of increasingly complex heists, such as stealing diplomatic papers from a travelling funicular railway, or breaking into a bank suspended thousands of feet in the air.

The thieves aren't smash-and-grab thugs, however. Instead, they use portable computer 'decks' to slice through security systems with surgical precision.

Intriguingly, Quadrilateral Cowboy lets you get hands on with the hacking yourself. Your deck can be physically placed anywhere in the game world, and you use your own keyboard to input commands directly into its interface. Doors can be opened, lasers deactivated and surveillance cameras shut off, all via the game's simple programming language.

Like Duskers, Quadrilateral Cowboy's use of a command line interface as a game mechanic has incredible immersive potential. The game further adds to its unique flavour with its drip feed of new gadgets, including a bounce pad that catapults you across the map, and the excellent Weevil – a flea-like drone that can be remotely controlled from your deck by inputting commands such as Go, Turn and Jump. You can even manually connect to the Weevil's own CCTV feed, viewing its movements in first person on a chunky monitor readout.

It's a colourful and engaging collection of systems, but the game itself fails to live up to the expectations they set. In-game missions are actually simulations played out on a primitive VR headset that runs on cassette tape, and they comprise lots of small levels that are used repeatedly for different challenges. These missions are further broken up by cutscene-like interludes that offer a glimpse of the wider game world but, frankly, little else. It's very lofty and meta, but it isn't absorbing.

All those brilliant systems and gadgets simply aren't given sufficient room to breathe either. While levels seem airy and open at first, it soon transpires that each puzzle has a single solution, which you'll only find after several failed attempts. Quadrilateral Cowboy is desperate for some broader spaces that let the player experiment with different pathways and solutions.

It's a shame, because Blendo Games has laid all the groundwork for an irreverent and inventive immersive sim – a Thief with computers.

However, it fails to build on these foundations; it's too fixated on being a clever game instead of a decent one. Chung has promised additional levels in the future, but for the moment, Quadrilateral Cowboy is a collection of great ideas that fails to gel into a coherent game.

RICK LANE

OVERALL SCORE
57%

/ VERDICT
Plenty of good ideas and fun gadgets, but Quadrilateral Cowboy fails to gel these elements into a coherent game.

box.co.uk

cube

Box Limited recommends Windows

Home
Windows 10
Microsoft

DESIGN YOUR ULTIMATE CUSTOM PC

+ RAM, COOLING, MOTHERBOARD & MORE

YOUR PC - YOUR CHOICE - DEFINE YOUR DESTINY!

Configure yours now at **box.co.uk/custom**

LATEST GEFORCE® GTX 1070/1080 VR READY GAMING PCs

Cube Tension VR

- MSI GeForce® GTX 1070 8GB
- Intel Core i5 6600K 3.5GHz
- **Windows 10**
- 16GB **DDR4** HyperX RAM
- 480GB SSD + 1TB SSHD
- 2 Year Warranty

GEFORCE GTX VRREADY

From **£1399***

Cube Minotaur X99

- MSI GeForce® GTX 1080 8GB
- Intel Core i7 6800K 3.4GHz
- **Windows 10**
- 16GB **DDR4** 3000Mhz RAM
- 240GB SSD + 2TB SSHD
- 2 Year Warranty

GEFORCE GTX VRREADY

From **£1899***

Cube Leviathan SLI

- 2x MSI GeForce® GTX 1080 8GB SLI
- Intel Core i7 6700K 4GHz
- **Windows 10**
- 16GB **DDR4** HyperX RAM
- 240GB SSD + 1TB SSHD
- 2 Year Warranty

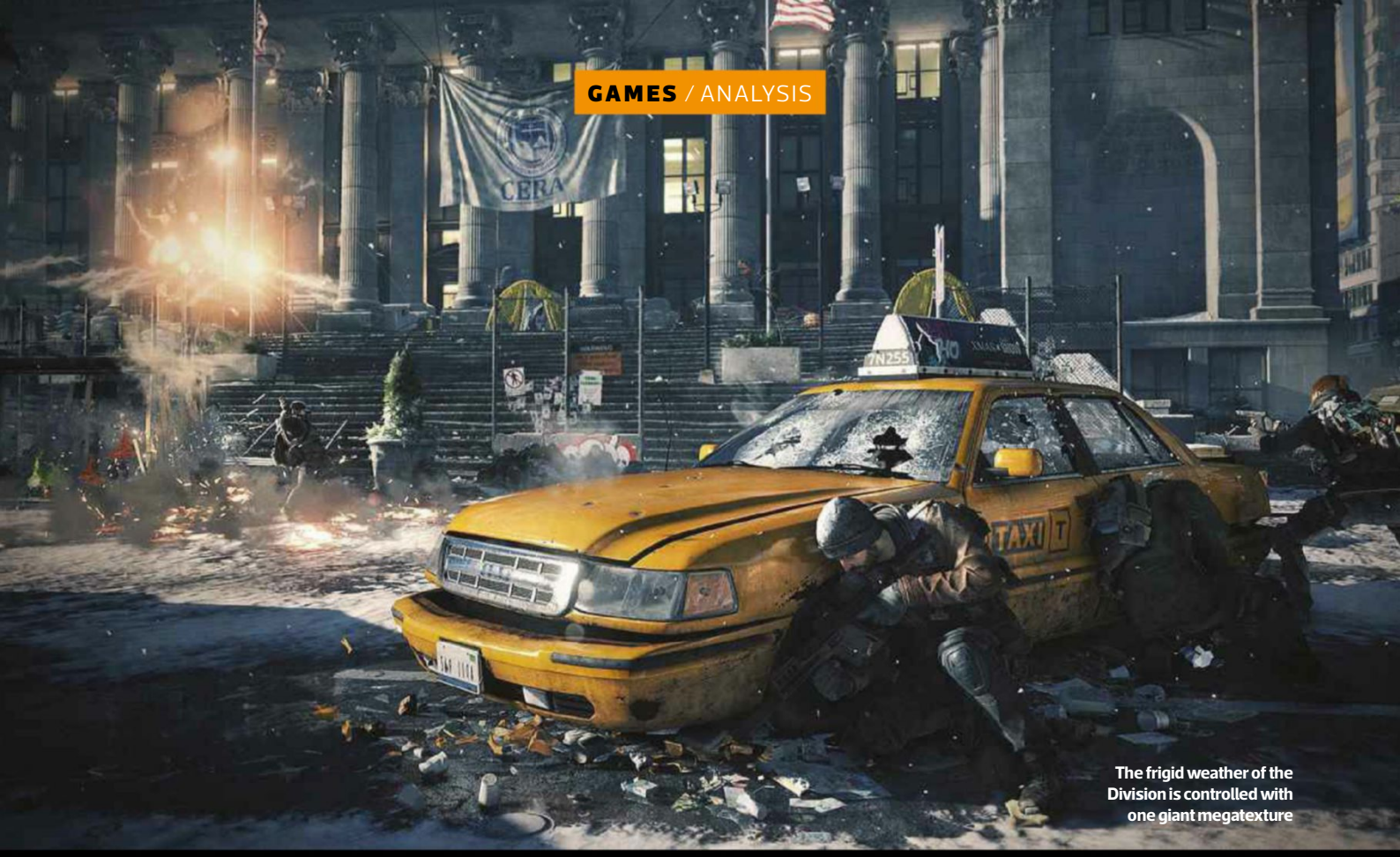
GEFORCE GTX VRREADY

Only **£2449***

Buy online at **www.box.co.uk** *Or visit our Birmingham Store*

VISA · VISA Electron · DELTA · Solo · Switch · MasterCard · Maestro · PayPal

*Prices & offers are correct at time of going to press and are subject to change without notice. Nothing in this advert forms part of any contract. Prices are inclusive of VAT at the current rate of 20%. Box.co.uk is a trading name of Box Limited.



The frigid weather of the Division is controlled with one giant megatexture

RICK LANE / THE ENGINE ROOM

Snowdrop

Rick Lane speaks with Ubisoft Massive about the technology behind The Division

New York is a cultural staple for disaster media. The Big Apple has been mulched into cider in films ranging from King Kong to Independence Day, while players have run rampant in Manhattan in games such as Max Payne and Crysis 2.

Tom Clancy's The Division represents the most expansive representation of New York in the grip of a crisis yet, as players join together to patrol its snowbound streets, trying to restore order after a deadly virus outbreak.

With highly realistic visuals and large-scale, persistent multiplayer gaming, The Division is one of the most technically ambitious games released this year. Powering that ambition is Snowdrop, Ubisoft Massive's bespoke engine, and the Division is the first game to use it. According to Massive senior system architect Christian Savoie, however, it isn't just technical fortitude that makes Snowdrop a powerful tool.

'The two biggest pillars that drive the Snowdrop engine are iteration and flexibility,' Savoie explains. 'To provide the scale of experiences that players expect, we need good tools. Not only do the tools need to be able to craft large amounts of data, but they need to do it quickly. Snowdrop isn't just a powerful engine, it's also very fast. In most cases, developers can see their changes in the game instantaneously.'

Iteration times are one of the biggest drains on time and money in game development. In the past, it was common during development projects for designers to wait hours, sometimes even days, for a new build of a game to load. Even today, being able to see those changes instantly is a massive boon.

Convenience seems to be a theme for Snowdrop. One of the engine's key features is its node-based scripting system, which enables developers to clearly see the web of interactions between different assets within the game. 'Our node-based scripting system starts with a set of data describing the actions to perform, which it then converts into byte code that's interpreted by the engine into commands for the game,' Savoie explains. 'A node is similar to a script command, but when working with Snowdrop, you get to see how it connects to and relates to all the other commands. You can follow the flow of data and get a much deeper, intuitive, understanding of the system in which you're working.'

Ubisoft Massive uses its node system in many areas of The Division's design, including animation, UI, AI and shaders, but

it isn't universally applied. 'It's mainly applied in areas where we want to empower our designers and artists to take more control over their work. There are still many areas of development that we leave in code for both performance and security reasons,' Savoie adds.

Other areas where speed and convenience are vital for Snowdrop include networking and asset rendering. Regarding the former, reducing lag was a crucial aspect of making The Division work as a large-scale multiplayer shooter. 'We've been able to build our systems so that the user input always processes the same frame that it's received,' Savoie explains. 'This gives a range of around 20-50ms from when the user presses a button and that information is sent across the network.' In addition, the team focused on minimising the amount of data that needed to be sent across the network, and optimising performance on the server side. 'Snowdrop has a large suite of performance profiling tools, from live profilers that can tell you exactly what's going on at that moment, to offline profilers that can tell us how servers behave over weeks of use,' Savoie adds.

As for rendering, The Division's use of New York as a setting necessitates a large number of assets with high-polygon density. Objects such as cars and buildings are traditionally far more graphically expensive than trees or outdoor terrain. To ensure optimal performance, Snowdrop employs what Savoie calls 'aggressive culling systems', to reduce information load. 'Our world assets are crafted very carefully, so they can be interactive and dynamic when necessary, but they cost nothing when they're not needed. While there may be millions of objects streamed around you, only a handful of objects are actually updating in each game frame.'

Moreover, Snowdrop only renders what's viewed on screen, through careful manipulation of both the CPU and GPU. 'The CPU is used to filter out objects off-screen, and the GPU is used to filter out objects that are completely occluded,' Savoie says. 'Normally these processes are quite computationally expensive but, as Snowdrop is a very multithreaded engine, we can hide a lot of the cost by interleaving in the space between other systems updating.'

This emphasis on speed and responsiveness in the engine also allows plenty of room to make the most of the latest graphics techniques. The Division makes plentiful use of the usual suspects, such as temporal anti-aliasing, screen space reflections and so on. Savoie is particularly proud of The Division's global illumination system, which is directly based on the lighting of New York itself. 'By doing some clever offline processing of New York, we were able to create a network of light probes that allowed us to simulate realistic radiance transfer between objects in the game world,' he says. 'This system allowed for accurate scattering of light throughout the game world, at any time of day, in any weather, indoors or outdoors.'

The Division's global illumination system is based on New York's own lighting

One other technology unique to Snowdrop is the way in which it represents the weather. The Division takes place during a heavy snowstorm, so the developers needed the ability to represent realistic snow and ice in all its forms throughout the city. 'We added one specific piece of technology to bring the snow to life in New York,' says Savoie. 'The snow system contains its own megatexture, which our artists can use to control the snow throughout the city. In a texture the size of the city itself, we can control how much it builds up, the wetness of the snow and even the depth of the footprints left behind as you walk through it.'

Although The Division is the first game to showcase the engine, Snowdrop wasn't built with The Division exclusively in mind. Like much of Ubisoft's tech, Snowdrop was built as a platform with which Massive could build other games, using its experiences with The Division as a way of further sculpting the engine. 'Since The Division's release, we've had long look back over its development. We're sorting through what decisions we took that worked, which ones didn't, what technologies we want to improve upon and which ones we want to replace,' Savoie concludes. 'For future projects, we'll look into how we can support even larger worlds. Once we can support larger worlds, we'll need to make a big investment in tools so that we can fill those worlds with interesting and fun things to do.' GPC

Snowdrop employs a variety of culling systems in order to maintain The Division's high density of assets

BUILD A GREAT GAMING PC FOR UNDER £1,000

Want to build a decent gaming PC that doesn't break the bank? Antony Leather shows you how to build a sub-£1,000 system with an Nvidia Pascal GPU and an unlocked Intel Skylake CPU

Now is a fantastic time to build a new PC. For starters, the furore of last summer's Intel Skylake launch has died down, so CPUs and motherboards are more reasonably priced than a year ago. Perhaps more importantly, though, mid-range GPUs are currently battling, with Nvidia launching the GeForce GTX 1060 and AMD releasing the Radeon RX480. At the moment, the Nvidia card just edges out the RX480, which costs around £20-30 less. However, prices are hovering between £200 and £250 for the cheaper models for both GPUs, so they're both great options for a sub-£1,000 PC. There are more great PC cases around than ever, plus SSDs are getting cheaper.

If you're looking to build a decent gaming PC that won't bankrupt you, then read on, because we've cherry picked our favourite hardware of the moment to construct an awesome PC for less than £1,000. It can tame any game up to a resolution of 2,560 x 1,440, it has a fast SSD, a liquid-cooled, overclocked CPU and it's housed in a great-looking future-proof case that provides plenty of room for expansion.

SHOPPING LIST

CASE

SilverStone Primera PM01 / £90 inc VAT

SUPPLIER www.scan.co.uk

There's are plenty of decent cases around at the moment, and ATX isn't the only option – there's plenty of scope for building a smaller system using micro-ATX and mini-ITX hardware too, which will take up less space while still offering plenty of power. We've opted for an all-singing, all-dancing ATX case, though, in the form of SilverStone's Primera PM01. It's a high-airflow case with plenty of ventilation and massive potential for expansion, especially when it comes to cooling. This great case will still give you change from £100, plus it's available in black or white with LED fans.

ALTERNATIVES

Decent alternative cases are NZXT's cheaper S340 and Fractal Design's Define S, while micro-ATX or mini-ITX fans should consider Fractal Design's Arc Mini R2 and Define Nano S.

CPU

Intel Core i5-6600K / £216 inc VAT

SUPPLIER www.overclockers.co.uk

It's still possible to use base clock overclocking to push the clock speed of a humble Core i3-6100 sky-high if you use a compatible motherboard and BIOS, but for this price league we're opting for a quad-core Core i5-6600K. It's a more flexible overclocker than the Core i3, as its multiplier is unlocked. It's also very fast as standard, plus it's much quicker and more efficient than any AMD equivalent.

ALTERNATIVES

For additional grunt with more CPU threads, perhaps for video encoding or rendering, the Core i5's pricier sibling, the Core i7-6700K is a better option, as it supports Hyper-Threading, which enables each core to split some of its resources and execute two threads simultaneously, effectively giving you four more virtual cores. A cheaper option is Intel's Core i3-6100, which you'll be able to overclock with a motherboard that has a base clock overclocking BIOS available.

MEMORY

8GB Corsair Vengeance LPX 2666MHz DDR4 / £39 inc VAT

SUPPLIER www.ebuyer.com

To keep down our PC's price, we've opted for 8GB rather than 16GB of RAM. This capacity is still enough for the vast majority of tasks, from gaming to photo editing, although if you regularly have dozens of browser tabs and programs open, plus several high-res photos in Photoshop, you should consider spending another £30 or so for 16GB. It's also worth looking at this month's memory Labs test (see p50). Corsair's Vengeance LPX memory does the job, but there are more lavish options available with LEDs and attractive colour schemes. Dropping to 4GB isn't recommended though – it won't save you much money, and it will result in noticeable performance drops in games and applications.

ALTERNATIVES

You can upgrade to 16GB for an extra £30 or so, but it's also worth considering Avexir and Corsair's LED DDR4 kits, which offer serious visual pizzazz for a little extra cash.

GRAPHICS CARD

Palit GeForce GTX 1060 6GB Dual / £250 inc VAT

SUPPLIER www.scan.co.uk

The graphics card market has shifted considerably in the last few months, thanks to new mid-range and high-end offerings from Nvidia and AMD, all of which are excellent choices depending on your budget. To build a PC for under a grand, you'll need to find a graphics card that costs less than £250, otherwise you'll end up cutting back on cooling, storage space or CPU power. The two logical options are Nvidia's GeForce GTX 1060 6GB and AMD's Radeon RX 480 8GB. The former gets our choice, thanks to its excellent efficiency and slightly better overall performance. However, prices vary wildly, with some GTX 1060 cards retailing for over £300. We've chosen Palit's GeForce GTX 1060 6GB Dual, as it costs just £250 and still has a comparatively quiet cooler.

ALTERNATIVES

AMD's RX480 is only slightly behind the GTX 1060 in terms of performance and efficiency – if you can find an RX480 card going cheap then it's still a great option. Also, watch out for GTX 970 prices dropping. As we were writing this feature, some models retailing for under £190 inc VAT.

MOTHERBOARD

ASRock Z170 Extreme4 / £115 inc VAT

SUPPLIER www.scan.co.uk

There are more than a few Z170 motherboards from which to choose, and as we said with your choice of case, there are plenty of great micro-ATX and mini-ITX options too if you need a small system. If you don't have loads of cash to splash, ASRock's Z170 Extreme4 rules the roost, offering an overclockable board with a few extra features for a reasonable price of £115. No other board comes close in terms of performance and features in this price range.

ALTERNATIVES

Asus' Maximus VIII Ranger is our board of choice for under £200. It's a great overclocker, has a fantastic EFI and it has loads of hardware and software features. For smaller systems, Asus' Maximus VIII Gene is a brilliant choice, and for mini-ITX fans, Asus' Z170I Pro Gaming is the best dinky board for under £200.

CPU COOLER

NZXT Kraken X41 / £71 incVAT

SUPPLIER www.alza.co.uk

As our case offers numerous 140mm fan mounts, it makes sense to opt for a 140mm all-in-one liquid cooler. Our favourite 140mm model is NZXT's Kraken X41, which outperforms Corsair's H75 and offers software-based tuning, enabling you to tweak noise and cooling power to your liking.

ALTERNATIVES

If you want to keep your budget to a minimum, you could ditch the liquid-cooling idea and opt for SilverStone's Argon AR01 air cooler instead, which is still a quiet and capable cooler. Stepping up to more advanced cooling, and more money, Alphacool's Eisbaer provides a great base for a custom water-cooled system.

SOLID STATE DRIVE

Samsung 256GB 850 Evo / £75 incVAT

SUPPLIER www.currys.co.uk

If you're gunning for a PC that costs less than £1,000, opting for a PCI-E NVMe M.2 SSD isn't the most economical option, as SATA 6Gbps SSDs cost half the price and are still massively quicker than a hard disk. That money is better spent on a faster graphics card, at least in this price range, and Samsung's 850 Evo offers a great balance of performance and value for money. You should aim for at least 256GB of storage space, as Windows 10 takes up well over 10GB of space on its own, quickly rendering a 128GB model short on space. The extra capacity is enough for several big games, such as GTA V, to be installed at the same time, while still giving you some room for other programs, with data stored on a hard disk.

ALTERNATIVES

You ideally want as much solid state storage as possible, and we highly recommend opting for a 500GB model to give you space for all your programs, games and operating system. As we saw in our SSD Labs (see p40) this month, you get much more bang for your buck once you get into the 500GB league. If your priority is fast storage, Samsung's 950 Pro is currently the best M.2 NVMe PCI-E option, but its successor – the Polaris-based 960 Pro , is slated to be turning up soon, offering even faster speeds and 1TB capacities. If performance is your priority, it's worth waiting a couple of months.

HARD DISK

Seagate 2TB Barracuda / £61 incVAT

SUPPLIER www.scan.co.uk

SSDs still can't compete with hard disks in terms of cost per gigabyte, so a traditional mechanical hard disk will still be useful for storing terabytes of data cheaply, especially if you have a large digital music and video collection. For £61, you get 2TB, giving you loads of space for data storage without clogging up your solid state space.

ALTERNATIVES

If you need more space, 4TB hard disks cost under £120. Alternatively, a decent NAS box will offer redundancy and plenty of features for sharing your data across your network and the Internet, as well as with smart TVs and media devices.

POWER SUPPLY

EVGA SuperNova GS 550W / £71 incVAT

SUPPLIER www.cclonline.com

PC components are now more efficient than ever, so you no longer need to consider a 1,000W PSU as an investment. A 500W PSU will cater for our Z170-based system fine, and our favourite model is EVGA's SuperNova GS 550W, which is fully modular and offers great stability and efficiency.

ALTERNATIVES

If you need a little more power for pushing all your overclocks to the limit, or if you plan to upgrade to a dual-GPU system in the future, Corsair's RM750i offers 200W more power, as well as great efficiency, modular cables and very quiet operation.

TOTAL PRICE £987 INC VAT

BUILDING THE PC

1 INSTALL CPU

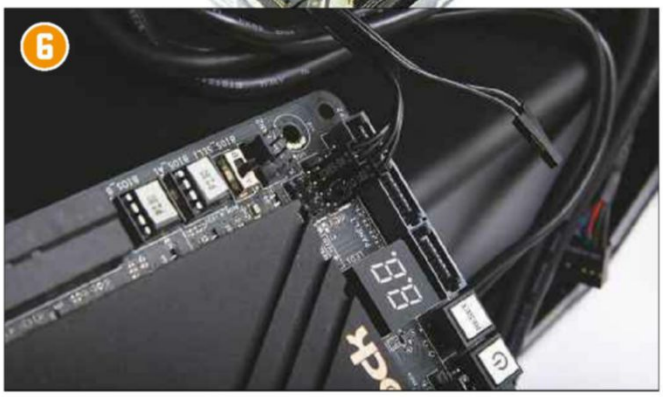
Remove the CPU protection cover, open the CPU latch and move the CPU over the socket at a low height – with this method, if you drop it, you stand the least chance of damaging the delicate pins inside the socket. Some motherboards include CPU installation tools as well, but the key is to be extremely careful not to bend any pins.

2 MOUNT COOLER HARDWARE

We'll be temporarily mounting the NZXT Kraken X41 to test our hardware out of the case, before it's installed, as most new Intel CPUs don't include stock coolers for quick and easy testing any more. If any of your components are faulty, which can happen, you then don't have to dismantle your whole system to diagnose any faults. Once you've tested all the gear, it's best to remove the pump and then install the motherboard in the case, as this process is difficult with the pump attached to the motherboard. The Kraken X41 uses a backplate and mounting screws to secure to the motherboard. Install these parts first, following the included instructions.

3 INSTALL PUMP

Secure the waterblock and pump section of the cooler to the mount using the four thumbscrews – thermal paste is pre-applied so you don't need to apply any yourself. You also need to attach the pump's power cable to the motherboard's CPU fan header, and the radiator fan to the cable coming off the pump. Don't worry about connecting the USB cable to your motherboard yet, as you'll need to remove the pump to install the motherboard in the case anyway. After that, attach the fan to the radiator using the long screws and leave



the radiator and fan to the side of the motherboard for the moment.

4 INSTALL RAM, GRAPHICS CARD AND POWER CONNECTORS

Place your motherboard on a cardboard box, or your original motherboard box, to use as a temporary test bench. Now install the graphics card into the top 16x PCI-E slot (the one nearest the CPU socket) and connect the 24-pin ATX, 12V EPS and PCI-E graphics power connectors from your power supply to your motherboard and graphics card.

Now is also a good time to hook up your SSD to a SATA power connector and a SATA port on the motherboard. All the SATA connectors on our chosen motherboard are controlled by the Intel Z170 chipset – on other boards, it's worth checking if there are any ASMedia-powered ports, as these will be much slower and could bottleneck a modern SSD.

5 CHECK EFI

You can now plug a mains cable into your power supply, plug a monitor into your graphics card's output, connect a keyboard and mouse to your motherboard's USB ports and power on the PC to make sure it's all working. To power on the PC, The ASRock Z170 Extreme4 motherboard has some convenient power and reset switches, but if you opt for a different board, use a small screwdriver to short the two power pins that normally connect to the case's power button, usually in the bottom right corner of the motherboard.

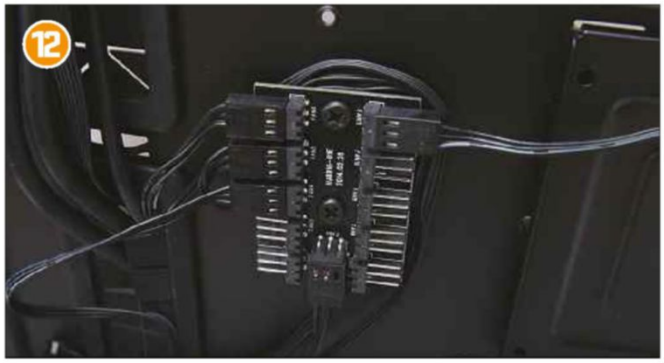
If your PC doesn't boot, turn off the power and try reseating the components, one by one – you want to get this right now, rather than when all the hardware is screwed into your case. The Z170 Extreme4 also has a two-digit POST code display in the bottom right corner, which you can check to help diagnose problems.

When your PC boots up, tap the Del key repeatedly as soon as a display appears, and you'll head into the EFI menu. Enable the XMP profile, under OC Tweaker / DRAM configuration, which will run the CPU and motherboard optimally and set the memory to the correct timings, voltage and frequency. Save and exit, then reboot – if it all works, you can switch off the PC and you're ready to install it in the case.

6 INSTALL MOTHERBOARD AND FRONT PANEL CONNECTORS

Remove the pump/waterblock unit of the cooler from the CPU mount, so you can easily install the rest of the cooler later. Then install your case's front panel header cables (for the power switch, LEDs and so on) to the motherboard before you install the motherboard in the case, as well as any USB or audio headers – they're very fiddly to install once the motherboard is screwed into the case.

There are dedicated headers for these plugs on the motherboard that are often clearly labelled but if in doubt, consult your motherboard's manual. Now go ahead and install the motherboard's I/O panel in the hole at the back of the case, then you're ready to install the motherboard. Make sure there are standoffs between the motherboard and case, which corresponding with the PCB's screwholes. They may be preinstalled, but it's



always worth double-checking that all the screwholes and standoffs line up, or you risk short-circuiting your motherboard on the case metal.

7 INSTALL PUMP AND RADIATOR

It's always best to position your cooler's radiator so that it exhausts air from the case, with the fan pushing air through it. This arrangement is easy to achieve by placing the radiator in either the roof or the rear of the case, and we've chosen the SilverStone PM01's rear 140mm fan mount to house our Kraken X41. Use the long X41's short screws to fix the radiator to the case from the outside. With the radiator attached to the case, go ahead and reinstall the pump.

8 INSTALL GRAPHICS CARD

The graphics card should be installed into the top large 16x PCI-E slot after removing the two corresponding PCI blanking plates at the rear of the case. You should be able to use the same screws to install it.

9 INSTALL SSD

We've chosen to use a 2.5in mount on the front of the motherboard tray to house our SSD, but there are also mounts on the rear of the tray if you don't want to show off your SSD and would prefer to keep the front of the interior as clear as possible. You simply need to screw the mount into the four screwholes on the underside of your SSD, then use the thumbscrew to secure the mount to the case.

10 INSTALL HARD DISK AND SATA CABLES

Your hard disk can only be installed in the case's lower 3.5in bays, so go ahead and fix it in place with the ports facing the rear side panel. Then thread the SATA cables through the cable routing holes as required, connecting them from the SSD and hard disk to the motherboard.

11 INSTALL PSU

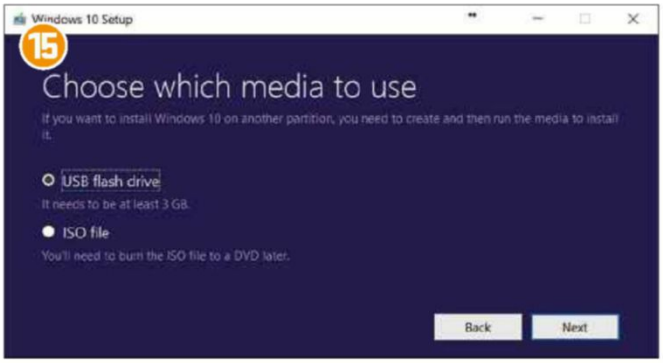
Most cases with a PSU cover require you to fit the PSU from the far side or rear of the case, and the PM01 requires you to slot it into place from the side, removing the right side panel first. Start by attaching any of the modular cables you'll need for your components, and leave extras – such as excess PCI-E power cables or Molex cables – in the box in case you need them at a later date.

12 CONNECT CASE FANS

You have two options for connect power to the PM01's case fans. If you want to control their speed, you'll need to hook them up to your motherboard. Otherwise, you can use the PM01's built-in 10-port fan hub, where they'll be fed a constant 12V supply. The front 140mm fans are relatively quiet anyway, but we're going to hook them up to the motherboard's spare fan headers instead of the fan hub, so we can control them through the EFI – this setup will result in a much quieter system when it isn't running games or heavy workloads.

13 TIDY CABLES

The PM01 case includes several large Velcro straps, which you can use to tie up any loose cables and keep the interior of the case as clean and tidy as possible – not only will



cable tidying make your PC look good, but it's better for airflow too. Use the cable-routing holes around the motherboard to thread your cables through to the motherboard, then strap these cables and the others together behind the motherboard tray.

14 POWER ON AND SET UP FANS

You can now hook up your monitor, mains cable, keyboard and mouse again. Switch on the PC, head into the EFI, hit F6 to enter Advanced mode (the key needed to enter Advanced mode may differ on other boards), and then head to the HW monitor section. Select the Silent mode for each fan to reduce its speed and noise, or fine-tune the fan's response to either the CPU or motherboard temperature in the FAN-tastic Tuning utility.

15 INSTALL WINDOWS

We haven't included an optical drive in this build because, if you're installing Windows 10, it's easy to create a USB drive to install the OS in a matter of minutes – much faster than a DVD. You can also buy Windows 10 on a thumb drive ready to install. If you have a DVD version, though, or just a key code, use another computer to head over to **http://tinyurl.com/win-tool-usb** in a web browser, so you can download Microsoft's Media Creation Tool. This utility enables you to download a copy of Windows 10, create the USB install disk and then install Windows.

On our ASRock motherboard, tap F11 during the bootup process, and you'll be able to temporarily select your USB thumb drive as a boot device to install Windows. Once you're sitting at the desktop, allow the system to install any updates, then install any drivers from your motherboard disc (checking for updated versions on the ASRock website first). You'll then need to grab the latest Nvidia driver from **www.nvidia.com** and install it.

Once Windows is all updated and all your drivers are installed, head over to **www.ninite.com**, where you can choose your favourite programs and download an exe file to grab the latest versions and install them automatically, which saves a lot of time faffing around with old DVDs and CDs.

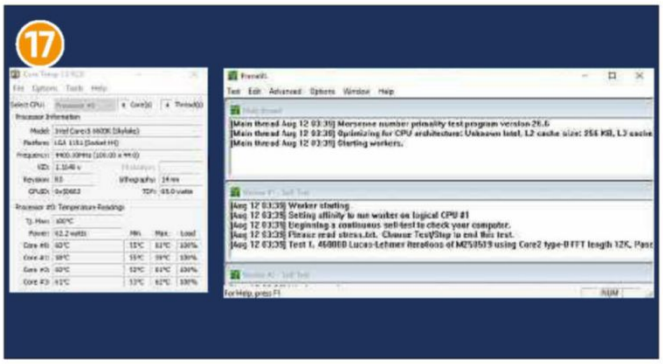
16 SET UP NZXT KRAKEN X41

Download NZXT's CAM software from **https://camwebapp.com** and head to the Kraken tab at the top. This software can enable you to set the Kraken coolers' fan to Silent mode, which still offers great cooling but much lower noise levels. You can use the software to monitor the fan speed and liquid temperature, which can be useful when overclocking.

17 OVERCLOCK CPU

We've found that 4.4GHz is an easy clock speed target for the Core i5-6600K, and 1.25V provides enough voltage to get there. Head into the motherboard's EFI again, find the OC Tweaker section and head into the CPU configuration options. Set the CPU ratio to 'All Core' and apply a 44x multiplier. While you're here, make sure the XMP profile is still set correctly – the memory should be running at 2666MHz.

Now go to the Voltage Configuration section and set the CPU core voltage to Offset Mode. This setting will enable the motherboard to downclock the CPU when it isn't under load,



saving power, but still ramp up to 4.4GHz with the correct voltage when under load. The offset voltage you'll need should be 150mV – this figure equates to 0.15V. You're aiming for a CPU vcore voltage of 1.25V, so check the current CPU voltage in the Hardware Monitor section on the right to see how much extra voltage you need to add. Our CPU voltage was 1.1V so adding 150mV (0.15V) brings the voltage up to 1.25V. Apply this setting, then save your settings and reboot. When your PC reboots, head into the EFI again and make sure the voltage in the Hardware Monitor section is around 1.25V – if not, tweak the offset voltage until you get there.

Once you're running at 4.4GHz with a 1.25V vcore, head into Windows to test these settings. Use Prime95 version 26.6 (**ftp://mersenne.org/gimps/p95v266.zip**) to load the CPU and CoreTemp (**http://www.alcpu.com/CoreTemp**) to monitor the CPU temperature. We found that, after ten minutes of stress testing with the Prime95 smallfft test, the CPU temperature at 4.4GHz didn't rise above 61°C, which is fine for an everyday overclock. However, if you see this figure regularly go above 75°C under load, you may want to drop the overclock and CPU voltage back a little, or increase the fan speed in the NZXT CAM software.

18 OVERCLOCK GRAPHICS CARD

The dual-fan Palit GTX 1060 Dual graphics card has a bit of overclocking headroom in it, and we increased the core by 100MHz from 1500MHz to 1600MHz and the memory to 2150MHz from 2000MHz. You can use MSI Afterburner (**https://gaming.msi.com/features/afterburner**) to overclock your card. Start by increasing the power limit and temperature limits to their maximum settings, then add 100MHz to the core and 300MHz to the memory, as shown in MSI Afterburner.

You may well find your card can overclock further than these settings, but these conservative figures should be achievable by most models. To stress-test your settings, run Unigine Valley (**https://unigine.com**) for 30 minutes. If your graphics card's core temperature doesn't rise above 80°C, and there are no glitches or hangs in the benchmark, you can either keep those settings or push them a little more, testing after you add every 10MHz to the core or memory.

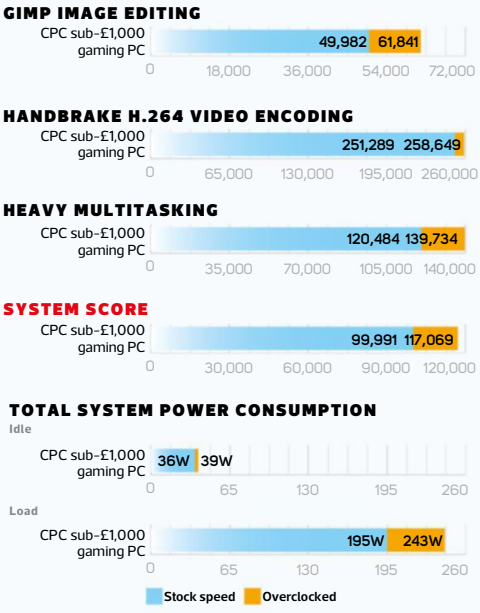
PERFORMANCE

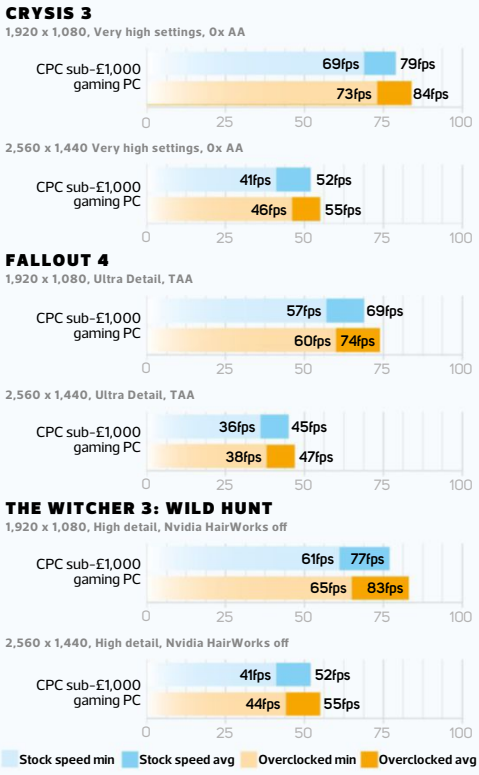
A stock-speed system with a Core i5-6600K and GTX 1060 is no slouch, but we managed to increase the benchmark results significantly. There was a near 12,000 point gain in our image editing test, rising from just under 50,000 to nearly 62,000 points, with the system score overall rising by over 17,000 points – an increase of 17 per cent.

There were noticeable differences in games too, with Crysis 3 gaining a 6 per cent and 12 per cent boost at 1,920 x 1,080 and 2,560 x 1,440 respectively, with similar numbers in Fallout 4 and The Witcher 3: Wild Hunt too.

As you can see from the graphs, this sub-£1,000 machine can happily handle games at demanding settings at a resolution of 2,560 x 1,440, with the lowest result of 36fps still being playable.

Thankfully, the load power consumption only rose from 195W to 243W when the system was overclocked with the CPU and GPU under full load, while the use of offset overclocking saw the idle power draw only rise by 3W. CPC





Element Gaming Carbon RGB Gaming Mouse

- RGB colour mouse with effects and customisable profiles
- 11 programmable keys (software included)
- Switchable DPI to a maximum 8200DPI and adjustable polling rate

£24.99

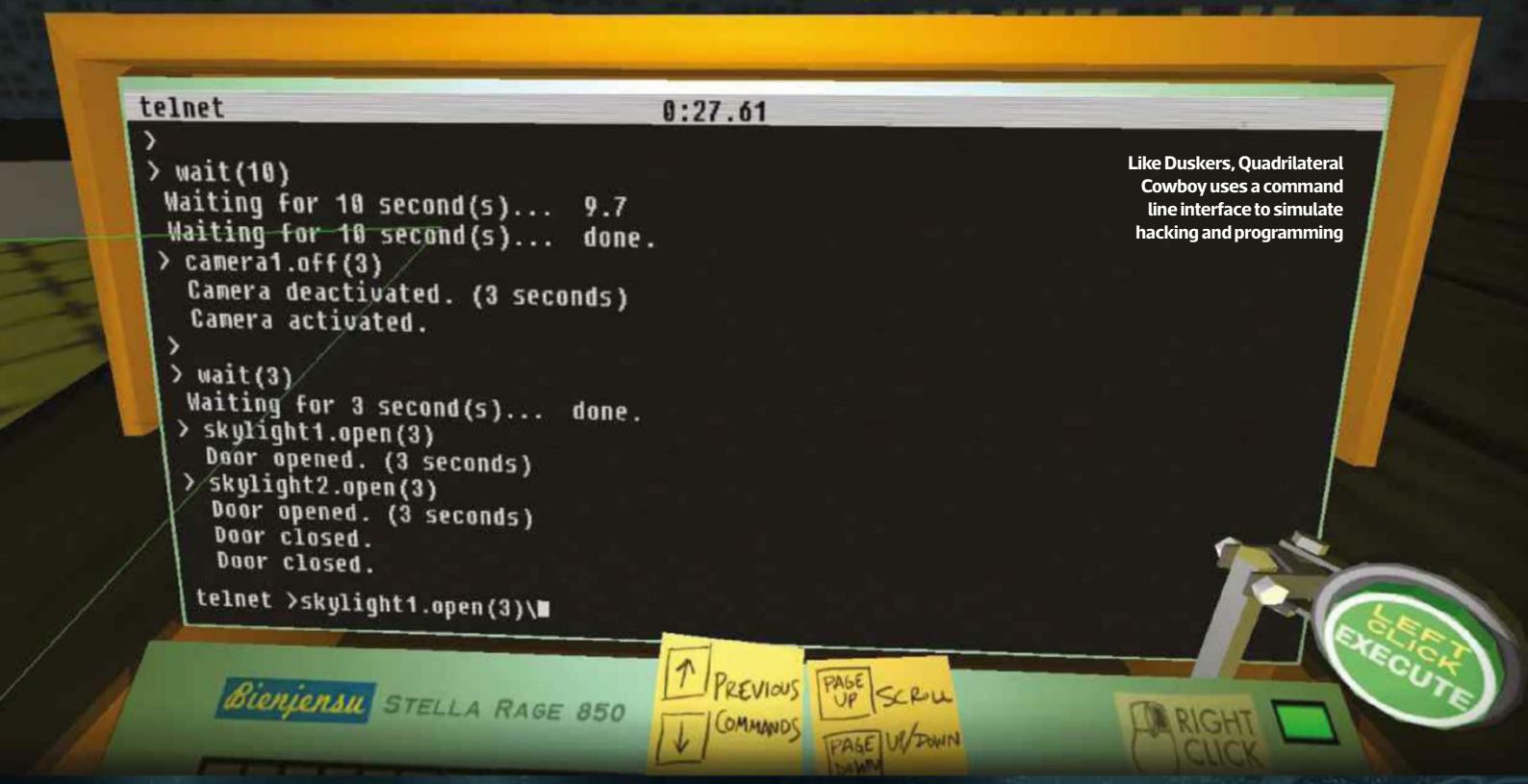
Element Gaming Carbon Mechanical RGB Keyboard

- N-Key Roll over (NKRO) for accurate gaming
- Record 7 groups of customised backlighting
- Multi-mode RGB backlight adjustment and customised effects
- Brown Mechanical Switches

£49.99

ELEMENT GAMING

ebuyer.com
FOR THE GAMER



Like Duskers, Quadrilateral Cowboy uses a command line interface to simulate hacking and programming

Regaining COMMAND

Rick Lane investigates the surprising return of the Command Line Interface as a game mechanic, and the crucial role it played in one of the best games of this year

Gaming often looks to the past for inspiration. You only need to look at the hundreds of indie-developed pixel-platformers from the past few years to understand that. However, some developers aren't just looking to the past for visual elements now, but also for the way in which players interact with their games. One particular mode of interaction that had previously been consigned to the dustbin of history is the command line interface (CLI).

Once the default method of controlling text adventures and early RPGs such as Zork, the command line interface died out when mice infested the desks of players. Until recently, you were only likely to encounter a command line interface in gaming if you were a developer, but there's just been a spate of games that have reintroduced command line interfaces to gaming.

In fact, these interfaces do more than simply provide a way for players to interact with the game; they've been reworked into a game mechanic in and of themselves.

Examples such as Quadrilateral Cowboy (see p82), which casts the player as an elite hacker, use command line interfaces to let players get hands on with simple hacking concepts. While it may sound like gimmicky, in the right hands, a well-implemented command line interface can completely transform your experience and enjoyment of a game.

Perhaps the most impressive use of a CLI in this manner can be seen in Duskers (see Issue 157, p78). Designed by indie studio Misfits Attic, and released earlier this year, Duskers is a survival game in which the player uses a fleet of remote-controlled drones to explore derelict spacecraft as they drift between the systems of a dying galaxy. It's one of the most uniquely terrifying games in existence, and its

CLI is crucial to how the game functions. 'Once I put the command line in the game, that was probably one of the most powerful moments for me as a game designer,' says Tim Keenan, founder of Misfits Attic.

Duskers began life as a very different beast. Keenan originally imagined it as an asymmetric cooperative game where one player wielded a gun while another controlled the game's only light source. 'You would board these derelict ships, or alien ships, or something like that,' says Keenan. 'One of you ran to the control room, the other one explored the ship and it would happen very much like Aliens.'

This initial idea went through several iterations. Recalling problems with his previous cooperative game, A Virus Named Tom, Keenan first scaled down Duskers to a single-player experience, using remote-controlled drones in place of the second player. The idea then evolved from a tower-defence game that played off the turret scene in Aliens, to a game with a much greater emphasis on exploration and survival. 'Then, for some reason, I decided that, since you were on your remote ship, we could add tension by letting the player tap into the computer system. Your enemies, when you found them, could come out and try to kill you and your ship,' Keenan explains.

Keenan took his prototype to a local game jam in San Francisco, where he showed it to several of his peers. 'I swear one of them said, "This would be really great with a command line interface," and I laughed at first because I sarcastically thought, "Yeah, I want to put a command line Interface in the game – as if A Virus Named Tom was going to make too much money or something!"'

Despite his reservations, Keenan opted to give the CLI a try, and it immediately improved the experience of piloting the drones. 'It was just a cube with lights on it, and it felt super-tense,' Keenan remarks. 'Manually issuing commands to the drones by typing feels real to me. If you watch NASA, they have this crazy technology where they're shooting things to other planets, but they're still typing on keyboards and trying to hack to make things work, right?'

Each spacecraft door can conceal unimaginable horrors. This particular horror is dead, but it could have been very much alive

Not only did the CLI make Duskers a better game, but it defined the course of development for the remainder of the project. Keenan's goal became to align the player's physical experience of the game as closely as possible with the idea of remotely controlling drones around an abandoned craft in the depths of space. 'You're not playing as the drone. You're not playing the drone operator. You *are* the drone operator,' Keenan emphasises.

'The drone operator would have the keyboard in front of them. The drone operator would have the monitor.'

The ultimate goal was to make the game so that, if the player were playing in a dark room, the difference between the drone operator's fictional setup and their own setup in real life would be zero.

In this way, the CLI determined other design aspects of the game. 'It freed me up to do whatever I wanted,' Keenan says. 'I started making all these decisions, like not having music in the game, because again that didn't make it feel real. There was a whole number of decisions that, as soon as I paused for thought, I would think, "I already put a damn command line in the game, so I'm not stopping now."' Keenan also disabled mouse control for every part of the game except scrolling the command line, because he didn't want players reaching for a mouse that wouldn't exist in the fictional drone control room. Meanwhile, the game's menu was designed to look like a retro-futurist boot screen for a drone operating system, so the immersion began the moment the player loaded the game.

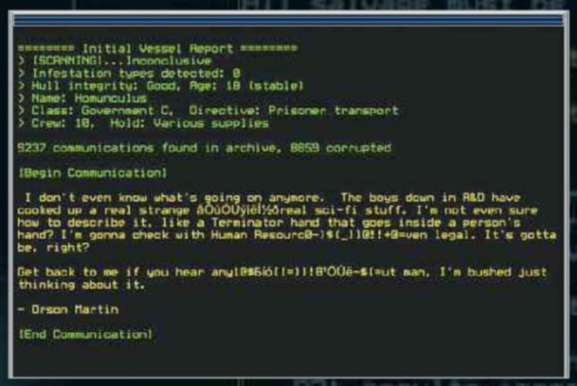
Duskers' commands are very simple, enabling players to quickly become adept drone controllers

The addition of the CLI even affected how Keenan designed the drones themselves. Initially, he planned to make them tug directly at the player's emotions. 'We were going to make them beep like R2D2, so they could complain if you put them in a room,' he says. But after the CLI went into the game, the level of immersion meant this feature was no longer necessary. Instead, players would become attached to the drones simply because of the powerful sense of isolation, and the intimate detail with which each drone is controlled.

The end result Keenan wanted was what he calls 'the Wilson effect,' inspired by the humanised volleyball in the film Cast Away.

Despite its radically different control scheme, art style and approach to interaction, Duskers has sold around 30,000 copies – enough to become profitable in an incredibly competitive indie scene. Although, the CLI that Duskers uses is far less convenient or responsive than traditional point-and-click controls used in other strategy games or roguelikes, it adds a level of engagement that redefines it entirely. Above all, the development of Duskers highlights the importance of the mode of interaction reflecting the type of game you're making, even if it happens to be 30 years out of date. **GPG**

Pre-mission summaries are presented as ship computer readouts



GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

INTERVIEW

Maker-friendly laser cutters

I catch up with Grant Macaulay from Theo Lasers about his plans to introduce affordable, low-power laser cutters for makers

'I gave my job up 18 months ago, after volunteering in a makerspace, and I saw that artists were coming in and cutting A4 sheets of paper on big industrial laser cutters,' Grant Macaulay told me at his stand during the Maker Faire UK earlier this year. 'I thought, "Right, I've been a maker, I've been making stuff under Creative Commons; I'm going to make a laser cutter and give it all away – the plans, Grbl and an Android mobile phone app."'

The result of Grant's surprise career shift was Theo Lasers, a small startup looking to crowdfund a family of affordable, open-hardware, reproducible laser cutters based on low-power laser diode technology. 'When I started out with the concept, I wanted a seven-year-old to be able to build and use it. I haven't quite managed the first one but I've managed the second.'

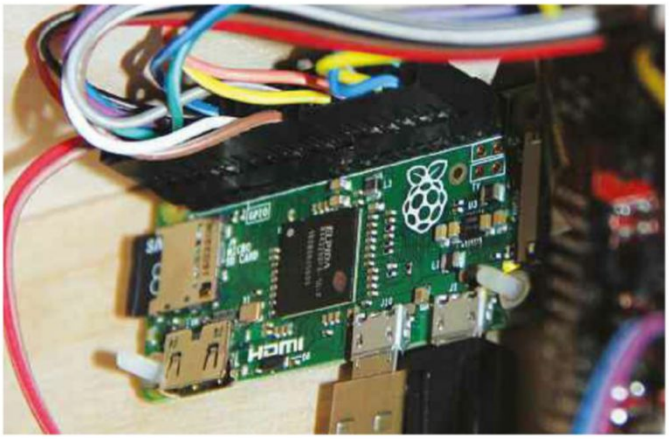
Although it's been fewer than three months since Maker Faire UK, Macaulay spoke with a renewed sense of excitement when he called me this month. He told me there had been a breakthrough. 'Initially, Theo was only based on the brilliant Arduino and powered by Grbl,' he explained, referring to his original design based on the popular open-hardware microcontroller platform and the open source computer numerical control (CNC) firmware implementation for it.

The idea of housing a laser cutter in a laser-cut wooden box is certainly novel, and makes for eye-catching hardware!

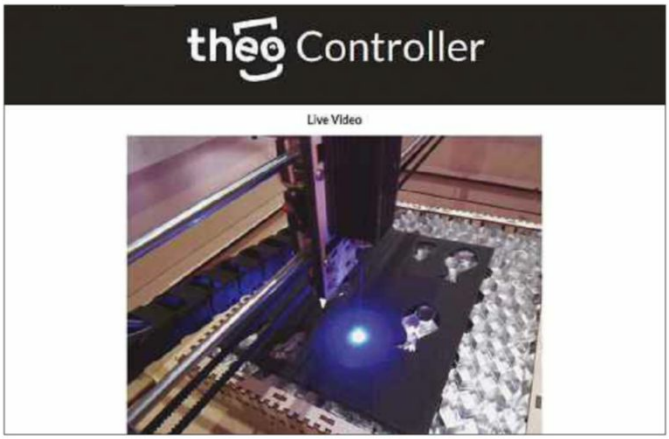
'I wanted more from this laser cutter,' he says. 'I dreamed of the full potential possible; what I was crying out for as a maker! I spent weeks banging my head against a brick wall, trying to get Grbl to do what I wanted. It wasn't working. I then phoned up my friend Gavin, who is a genius at programming, and asked him to have a look to give me some guidance. He was so enthusiastic; he turned to me and asked, "What do you want from me?" That list took me about eight hours!'

'The result was fantastic, far more than I could have possibly ever hoped for. What a morale booster! Gavin took Grbl, based on the Arduino Mega, converted the code to use the RAMPS 1.4 board, supporting an SD card, FSC display, Bluetooth and temperature sensor – which we're going to release back onto GitHub for the community, along with the

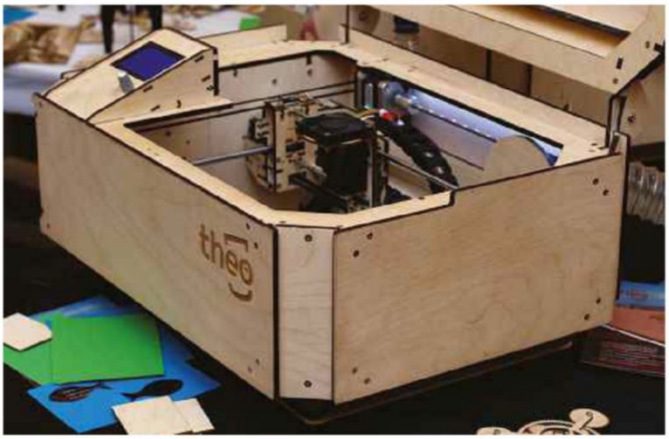
Despite the low power of the diode, Theo Lasers are capable of cutting very intricate work



The upgraded Theo Lasers are powered by the ultra-compact and low-cost Raspberry Pi Zero



A live stream from the Pi Camera Module lets you keep an eye on your project without getting near the laser



The entire design of each Theo Laser is open source, from the software to the laser-cut cases

case plans under Creative Commons. Then we found we were doing so much on the Mega that we had to move some of the functions to a new host.'

Anyone paying the slightest attention to the maker movement won't be surprised to hear Macaulay's choice for a new host. 'We turned to the Raspberry Pi, which opened up so many exciting possibilities and options! We immediately offloaded the peripheral devices, the SD card and display, and changed from an Android app and Bluetooth to Wi-Fi and browser-based software. This was all tested using OctoPrint. We've now gone on to develop our own web service called Theo Controller, which also allows for full photo engraving using several picture formats, and the progress can be monitored and recorded using the Pi Camera Module.'

While Macaulay's original concept – an Android application that allows the user to snap a photo of a drawing, convert it to a vector version and then send it to the laser cutter – is neat, the Raspberry Pi Zero-powered models are certainly an upgrade. The web interface runs entirely on the Pi and can be viewed using any device on the same network, with no need to install any software on your client device.

As well as directly controlling the laser cutter by uploading files for cutting, the Live Video feature also lets you keep a close eye on proceedings – a very clever addition given the slight risk of fire if the laser gets stuck, although that's less of an issue with the Theo's 1-5W diode lasers compared with an industrial cutter's significantly more powerful carbon dioxide lasers.

Grant Macaulay plans to offer three sizes of Theo Laser, with a choice of three laser diode output power levels

At the time of writing, Macaulay was still putting the finishing touches on a planned Kickstarter crowd-funding campaign that would see three models available for people to back: the Theo Mini, with a 200 x 250 x 50mm cutting area; the Theo Plus with a 250 x 350 x 100mm cutting area; and the Theo XL at 350 x 450 x 150mm. Three powers of laser are also planned: a 1W engraving laser and a choice of 3W or 5W cutting lasers.

Those without the budget to back the campaign, though, can still get involved: all Theo Laser designs and software are being released under permissive open source licences. 'Microslice, Ultimaker ... I've learned from these guys, and I want to give something back to the community and makers,' Macaulay explained of his altruism. 'I want to start the business, get it going, employ people and get a premises, but I'm giving something back as well.' Visit **http://theolasers.com** for more information.

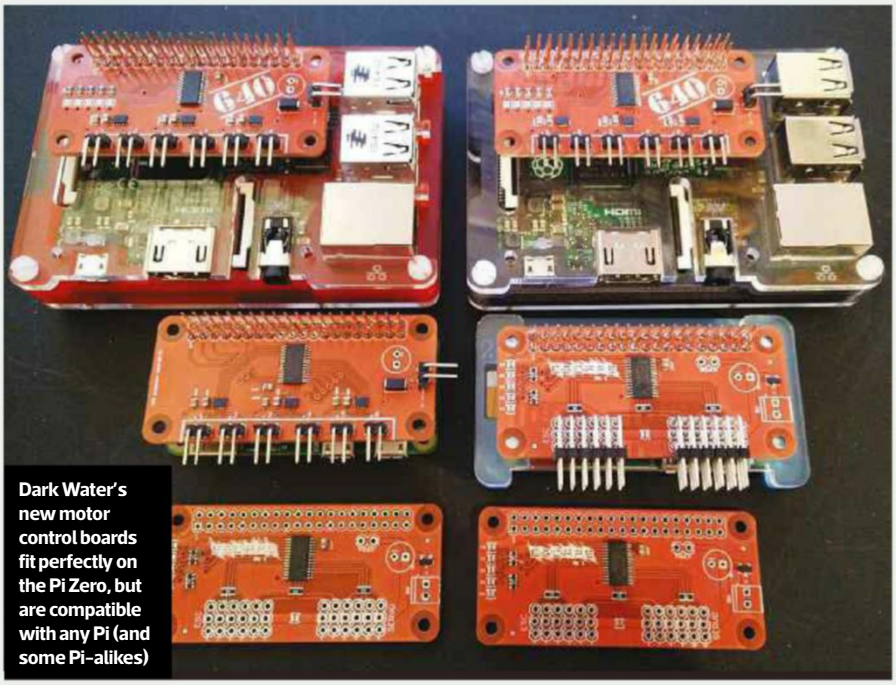
INTERVIEW

Underwater Pi robots

I chat to Dark Water's Barry Getty about his successful Kickstarter campaign to make Raspberry Pi robotics boards

The work of the Dark Water Foundation is a great indicator of the march of technology. Where traditional remote-operated submersible vehicles (ROSVs) are extremely expensive, Dark Water was started with a vision to use low-cost microcontrollers and single-board computers with Lego to build devices anyone can afford, but which are still capable.

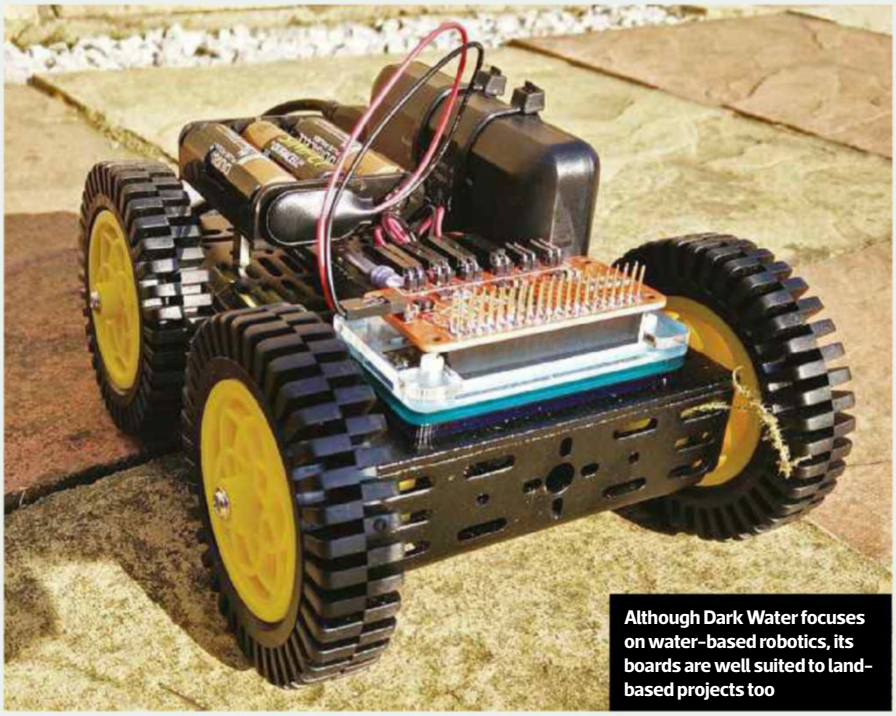
'We're trying to encourage people to do underwater robotics rather than on-land robotics,' Barry Getty explained of his non-profit organisation's goals when I met him at Liverpool MakeFest last year. 'This is our trial,' he said, waving at the kids building Dark Water ROSVs at the event's workshop ahead of a gauntlet to be run in a filled fish tank (minus fish) at the end of the table. 'Our aim is to get them into schools, maybe even colleges and universities – you never know.'



Dark Water's new motor control boards fit perfectly on the Pi Zero, but are compatible with any Pi (and some Pi-alikes)

Since MakeFest, Getty and his colleagues have been busy with a redesign thanks to a certain low-cost computer launch. 'The release of the Pi Zero late last year made us look at the Raspberry Pi platform afresh,' Getty told me ahead of a weekend of device-to-device communication testing. 'Any excuse for sea kayaking,' he joked. 'We could now fit an extremely capable Linux computer in a very small, and cheap, container – we just needed motor drivers that were the same size to fit on it.'

The move from a microcontroller to a fully functional microcomputer brought a considerable boost in capabilities with it, but existing motor controllers were either too big, too restricted or both. As with earlier problems, Getty's team came up with a solution in-house. The team's ultra-compact motor controller add-ons were designed to fit exactly within the Pi Zero footprint, with the Dark Control 640 designed for DC motors and the Escape board designed for Electronic Speed Control (ESC) motors.

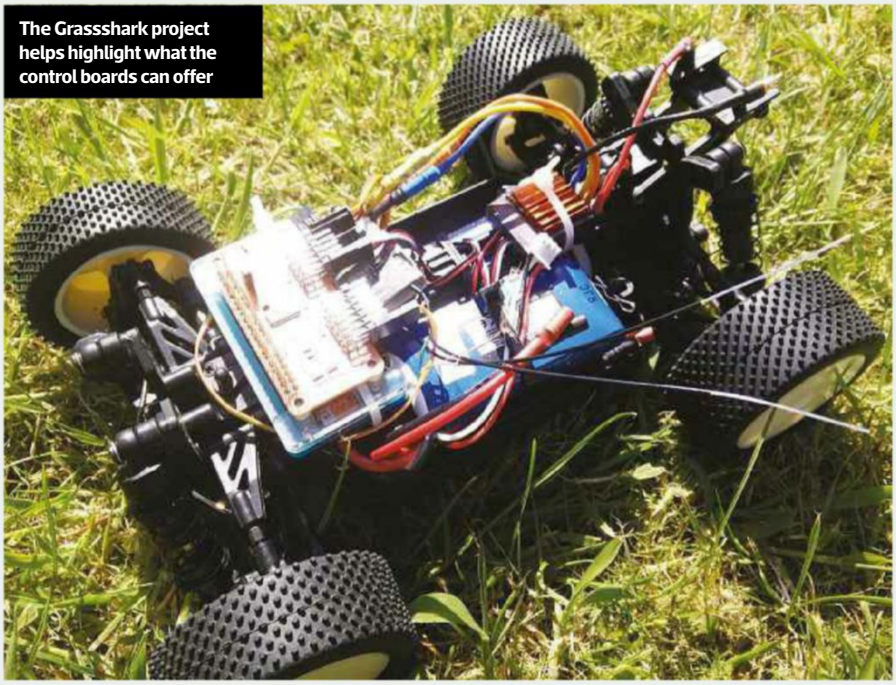


Although Dark Water focuses on water-based robotics, its boards are well suited to land-based projects too

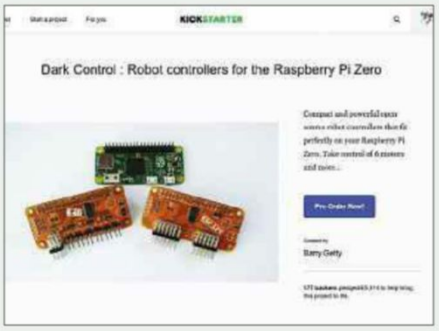
Both boards were also suitable for all sorts of ideas, from Lego projects to research-scale autonomous vehicles.

'The main difference between these boards and others is what we call "the power of six",' Getty told me of his team's creations. 'Both boards are capable of running six independent motors. For ground and flying robots, those extra motors might not be that big a deal, but six motors adds so much more for underwater robots. Six motors on an ROSV means you can allocate four motors to full vectored thrust for horizontal manoeuvrability, and two vertical motors for depth and tilt. For an underwater bottom crawler, you can get full four-wheel drive and an extra two motors to control stabilisation and lift.'

The story could have ended there, with the boards remaining an in-house product. 'We originally weren't going to make any more



The Grassshark project helps highlight what the control boards can offer



The Dark Control Kickstarter campaign finished its run with nearly 50 per cent more funds than it required for production

boards than we needed ourselves,' Getty told me. 'At this point, I thought that Kickstarter wasn't for us. We needed quite a large initial order and the average Raspberry Pi-based Kickstarter campaign goal was a lot lower than our necessary target. I listened to a lot of people and decided to take a chance – we spent two weeks getting the campaign ready, took a holiday and then released it. We hit 25 per cent of our funding within 36 hours.'

At the time of writing, the campaign had just passed its £4,000 goal on Kickstarter, with backers thrilled by the possibilities of the two boards, as well as the release of hardware and software design files under a permissive open source licence – an idea the Foundation has been keen on since its inception. For Dark Water, the success of the Kickstarter campaign is more than a means to fund production, it also represents a clear and unequivocal validation of the project's appeal.

'The boards were originally built for the "Over and Under Expedition', which we planned to fully 3D-map a body of water from the air down through to the depths. We need to build drones capable of flying above the area, mapping the ground, the shallows and at greater depth,' Getty told me of his planned applications for the controllers.

Dark Water's control boards have seen considerable interest from the radio control community

'So we need autonomous fixed-wing drones, quadcopters, ground vehicles, boats and ROSVs.

'We think the Pi Zero and these two boards will allow us to build and run all of these vehicles, and we'll be showcasing them over the next few months. Our aim is to encourage people to think outside of building hobby robots. If you can build a robot capable of driving around your living room, you can build something with an air quality sensor that can drive around a field – think outside of your living room and try to think of how your skills can help your community. I have huge hopes for the future. If we can encourage people to send off their robots into the world to explore, and publish the data they find then the world will be a better place.'

Visit the official website at **https://darkwater.io** for more information about the Dark Control board family and the rest of the Dark Water Foundation's creations.

It may not look like much, but this is the beginning of a remote-operated submersible vehicle (ROSV)

NEWS IN BRIEF

Eagle circuit visualiser released

Benjamin Richards and David ten Have's maker-centric development project, Omniblox, has released its first product: an open source visualisation tool for Eagle-format printed circuitboard (PCB) designs. Built on top of the Three.js WebGL library, Omniblox's Eagle-Loader accepts single boards as BRD files and renders them directly in a browser window in glorious 3D, complete with automated spinning and whizz-bang lighting effects. The initial release works well as a quick visualisation aid, and future releases will hopefully add features such as the ability to render components. The tool is available to everyone from **http://omniblox.io**

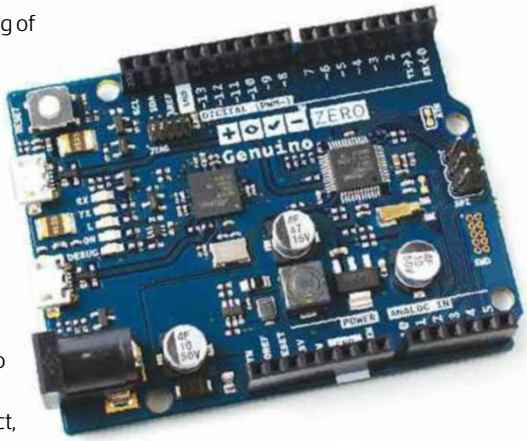
REVIEW

Genuino Zero

The Genuino Zero follows a string of split-personality devices from Arduino.cc, thanks to the ongoing trademark dispute with Arduino.org. In the UK, the Zero is a Genuino product, but in the USA, you'll find it under the Arduino brand. Don't, however, confuse it with the Arduino Zero Pro, a modified version made by Arduino.org. Clear? No, but with the lawyers involved, it's the best we'll get.

Nomenclature aside, the Genuino Zero initially looks like a slightly busy Arduino Uno. The familiar footprint is entirely intact, although there's one immediate difference that leaps out: there are two micro-USB ports on the board's left-hand edge, where an Uno would have a single USB port.

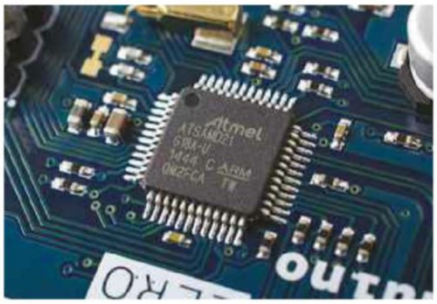
These ports reveal two of the Zero's prime selling points: a built-in JTAG debugger, and the ability to act as a USB host. The former provides a neat way to monitor your creations or recover from flashing a program that puts the Zero into a permanent sleep mode, causing it to disappear from the Arduino IDE – an example that's entirely hypothetical and not something I'd stupidly done within minutes of receiving the Zero. The latter, meanwhile, allows you to connect USB peripherals, including keyboards, mice and serial devices, and interface with them directly on the Zero.



It may look like an Arduino Uno, but the Genuino Zero is a considerable upgrade over the Uno

Like most other Arduinos, it's also possible to use the second port – described on the board's silkscreen as 'Native USB' – to turn the Zero into a USB device, emulating a Human Interface Device (HID) with ease.

Another change from the Uno comes with the Zero's switch to an ARM Cortex-M0+ ATSAMD microprocessor. While this choice drops the pins from 5V to 3.3V logic – which would be an issue if you were hoping to use a 5V shield add-on with that tempting Uno-like pin layout – it increases the power available considerably. Where an Arduino Uno hits 1.17 MWIPS Whetstone and 6.25 MIPS Dhrystone scores in benchmarking, the Zero manages a much more impressive 2.11 MWIPS Whetstone and 23.71 MIPS Dhrystone.



The Zero's ARM Cortex-M0+ microprocessor is surprisingly powerful

The memory is also boosted, which is great news for anyone who has found themselves limited by the 32KB of flash and 2KB of dynamic SRAM of the ATmega328-based Uno. The ATSAMD chip boasts 256KB of flash memory, allowing for considerably bigger programs, and 32KB of dynamic SRAM. Gone, however, is the 1KB of EEPROM storage found on the ATmega-based Arduinos, although if your sketches rely on this storage, they can be modified to force the Zero to emulate up to 16KB of EEPROM in flash.

There are further upgrades on the board: 20 digital pins compared to the Uno's 14, ten of which support pulse-width modulation (PWM) output. While the count of six analogue pins is evenly matched between the two boards, the Zero offers 12-bit resolution over the Uno's 10-bit resolution. A single analogue output is also included, boasting a 10-bit resolution, for projects where simulation via PWM control isn't suitable.

Sadly, all these extras come at a cost. The Genuino Zero costs £39 inc VAT from **https://shop.pimoroni.com**, while an official Uno costs £22 inc VAT from **http://oomlout.co.uk**. Bring in the clones and the gap is even larger: a knock-off Uno can be bought for as little as £3 (VAT exempt if the total order value is under £18) from **www.aliexpress.com**

Still, there are reasons to pick up a Genuino Zero. If you need high performance, high resolution, analogue output, more memory or USB host support, there's little out there to match it, and I already have a few projects in mind for mine. CPC

NEWS IN BRIEF

Raspberry Pi 3 Compute Module due this year

Eben Upton, co-founder of the Raspberry Pi Foundation, has announced that the long-overlooked Compute Module is to get an upgrade to match the specifications of the newer Raspberry Pi 3. While the upgraded Compute Module won't include integrated Wi-Fi or Bluetooth – any such feature would be installed on the break-out board instead – it will include the latest BCM2837 system-on-chip with four 64-bit Cortex-A53 processing cores and 1GB of RAM. While the Compute Module has seen some small uptake in industrial projects, the launch of the significantly cheaper, yet faster, Raspberry Pi Zero left the product in a state of limbo. The Foundation hasn't confirmed pricing or official availability yet.

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

DOWNLOAD FROM WWW.ASUS.COM/CAMPAIGN/REALBENCH

CUSTOM PC REALBENCH 2015

in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than more CPU cores.

Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake H.264 video encoding test takes full advantage of many CPU cores, pushing them to 100 per cent load.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. CPC

SHOUT OUTS!

We've had a bit of a shakeup in the leaderboard this month, with two new entries in the top ten from mikey and smudgesmif. Congratulations also go to new entries roosauce at seven and simonedwards2003 at 15. It's been great to see Broadwell-E and Pascal hardware hitting the leaderboard this month too.

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

CUSTOM PC REALBENCH 2015 LEADERBOARD

RANK	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	275,683	240.9%	8pack	Asus Rampage V Extreme	Intel Core i7-5960X	5.5GHz	16GB Kingston 3000MHz	Nvidia GeForce GTX Titan X
2	233,375	203.9%	ian.parry3	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	32GB G.Skill 3200MHz	Nvidia GeForce GTX Titan X
3	231,781	202.5%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	Not reported	32GB Kingston 2666MHz	Nvidia GeForce GTX Titan X
4	229,929	200.9%	mikey	Asus Rampage V Extreme	Intel Core i7-5960X	4.44GHz	16GB Corsair 2709MHz	Nvidia GeForce GTX 980
5	228,314	199.5%	smudgesmif	EVGA X99 Micro 2	Intel Core i7-6950X	Not reported	16GB Corsair 3200MHz	Nvidia Titan X (Pascal)
6	221,477	193.5%	Chris_Waddle	Asus X99-Deluxe	Intel Core i7-5960X	4.62GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX Titan X
7	219,938	192.2%	roosauce	Asus Sabertooth X99	Intel Core i7-5960X	4.69GHz	64GB Corsair 2446GHz	Nvidia Titan X (Pascal)
8	219,415	191.7%	Luke@DinoPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	16GB Corsair 3276MHz	Nvidia GeForce GTX Titan X
9	216,006	188.7%	terrystone1	Asus Rampage V Extreme	Intel Core i7-5960X	4.61GHz	16GB Corsair 2992MHz	Nvidia GeForce GTX 980 Ti
10	215,694	188.5%	dubai1	Asus X99-Pro/USB 3.1	Intel Core i7-5960X	4.7GHz	32GB Corsair 2800MHz	Nvidia GeForce GTX 980 Ti
11	212,062	185.3%	TEL	Asus Rampage V Extreme	Intel Core i7-5960X	4.62GHz	16GB Corsair 2750MHz	Nvidia GeForce GTX 980 Ti
12	211,331	184.6%	Menthol	Asus Rampage V Extreme	Intel Core i7-5960X	Not reported	32GB G.Skill 3200MHz	Nvidia GeForce GTX 980 Ti
13	208,975	182.6%	Angel	Asus X99 Deluxe	Intel Core i7-5960X	Not reported	128GB G.Skill 2448MHz	Nvidia GeForce GTX 980
14	206,723	180.6%	stuart	Asus Rampage V Extreme	Intel Core i7-5960X	4.41GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 780 Ti
15	203,784	178.1%	simonedwards2003	Asus X99 Deluxe II	Intel Core i7-6950X	Not reported	64GB Corsair 2666MHz	Nvidia GeForce GTX 980 Ti
16	198,971	173.9%		Asus Rampage V Extreme	Intel Core i7-5960X	4.4GHz	64GB Corsair 2400MHz	Nvidia GeForce GTX 980 Ti
17	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2400MHz	AMD Radeon R9 200 Series
18	193,102	169%	Nik	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	64GB Corsair 2666MHz	Nvidia GeForce GTX 1080
19	189,230	165.3%	shadowsrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980
20	185,219	161.8%	dax	Asus Rampage V Extreme	Intel Core i7-5960X	3.97GHz	32GB Corsair 2448MHz	Nvidia GeForce GTX 980

ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Poor water-cooling support for small Pascal cards

When the GTX 960 was launched, it seemed a foregone conclusion that waterblock manufacturers wouldn't release waterblocks for it, as it had a fairly low TDP, and many third-party cooling systems had fans that could switch off under low loads too. The situation was annoying for me, though, as I always water-cool my graphics cards so that I can eliminate fan noise all the time, even in games, and to make sure I get maximum overclocking headroom.

Plus, as the rest of my system is water-cooled, I'd much rather water-cool the graphics card for aesthetic reasons. Also, my office gets pretty toasty in the summer, so using a behemoth of a graphics card just isn't an option in my quiet mini PC. As the GTX 960 had the grunt for my gaming needs, as well as being small enough to fit into my dinky mini-ITX system, it was the perfect option, except there were no full-cover waterblocks for it.

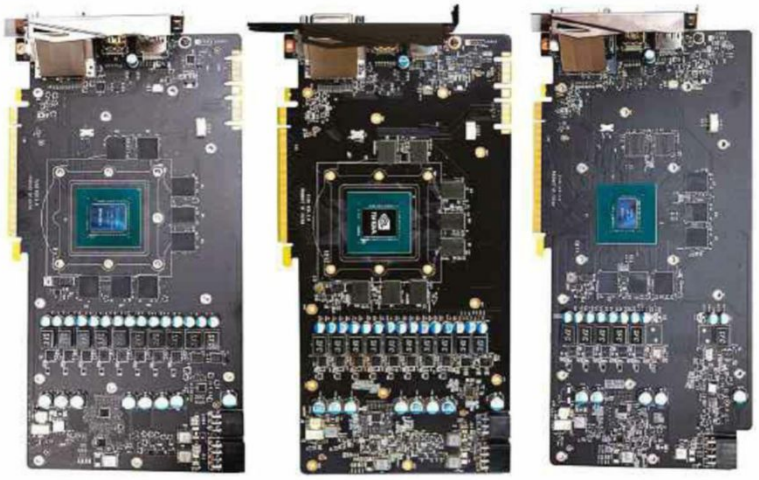
Thankfully, Bitspower eventually relented and released a waterblock for Asus' Strix GTX 1060, which is the card and waterblock combination that's currently residing in my system. In short, water-cooled GTX 960s are incredibly rare and, as far as I know, only one model – the Asus Strix – ever received a full-cover waterblock.

Only one GTX 960 card received a full-cover waterblock – an Asus Strix model

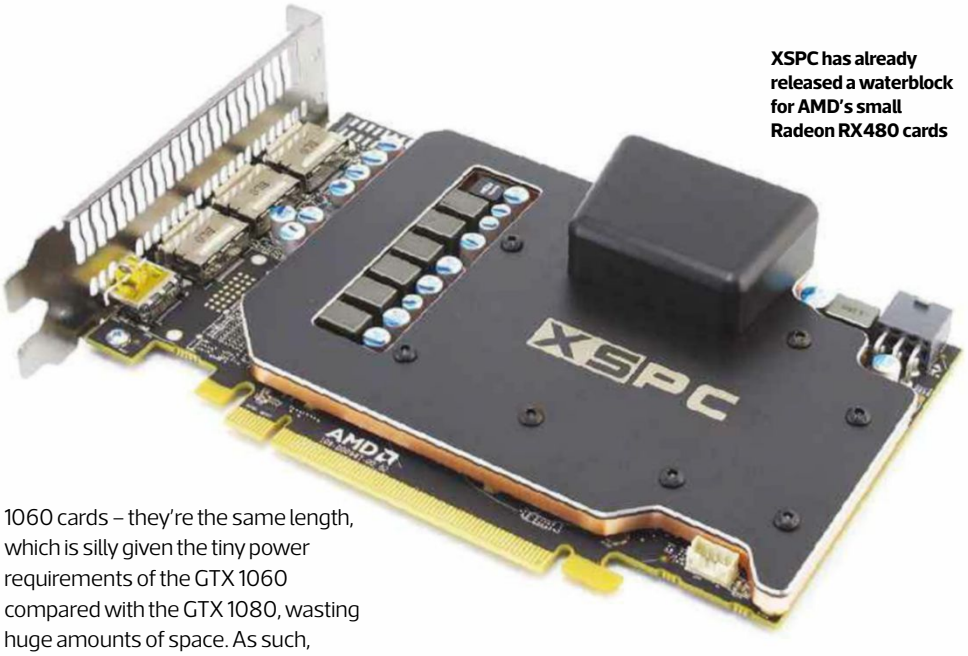
Fast forward to 2016, and the GTX 1060 is a slightly different beast. It costs well over £200 – significantly more than the GTX 960 cost at launch – and has a slightly higher power draw too. From the outset, this means waterblock manufacturers are supporting it with full-cover waterblocks. That's good, of course, but there's also an issue I've spotted while researching waterblock and PCB compatibility – it seems there are three or four distinct variations of GTX 1060 PCBs.

Some cards have a reference design, including Nvidia's Founders Edition models, which have an awkwardly placed power connector that's mounted on an extension cable, making it tricky to water-cool. Thankfully, some reference PCB designs have found ways around this problem, but few, if any, are supported by waterblock manufacturers.

Secondly, many board partners are using very similar PCBs for their GTX 1080, GTX 1070 and high-end GTX



The PCBs for MSI's GTX 1060, 1070 and 1080 cards are all roughly the same size



XSPC has already released a waterblock for AMD's small Radeon RX480 cards

1060 cards – they're the same length, which is silly given the tiny power requirements of the GTX 1060 compared with the GTX 1080, wasting huge amounts of space. As such, companies such as EKWB are able to offer a single GTX 1080-labelled waterblock for all three GPUs.

That's good news for enthusiasts, as it's likely that just one or two waterblocks will be needed to cover entire ranges of GPUs. MSI's Gaming X range of GTX 1060, 1070 and 1080 models, for example, are all compatible with the EK-FC1080 GTX TF6 waterblock. It's bad news for anyone wanting to water-cool a small PCB GTX 1060 card, though, as it's unlikely we'll see any waterblocks straying outside of support for these standard, large PCBs.

It's a real shame, as these small GTX 1060 cards are perfect for small form factor water-cooled systems. They're able to handle 2,560 x 1,440 gaming and they're faster than a GTX 970 in most games, yet they consume barely any more power than a GTX 960 card. The same is true for the GTX 1070 – very few of the cards with smaller PCBs have compatible full-cover waterblocks at the moment. However, as the GTX 1070 is a higher-end GPU than the 1060, there's more hope for mini GTX 1070 waterblocks further down the line.

Thankfully, there's an alternative if you want a small, power-efficient GPU that can squeeze into small spaces and is compatible with full-cover waterblocks. AMD's Radeon RX480 is a little cheaper than Nvidia's GTX 1060,

almost as fast in games and only a little more power-hungry, but it has a vast amount of full-cover waterblocks available for it from EKWB and XSPC, to name just two manufacturers.

Easy leak testing

Making sure your water-cooling loop won't sprout a leak when you fire up the pump is an essential part of creating a water-cooled PC. Even many non-conductive liquids can become conductive over time, as the metal waterblocks come in contact with the coolant, and even a small leak can have disastrous consequences. Leak testing can be a time-consuming process, and there are many methods.

It's always best to power on the pump without switching on the rest of the system, so if there's a loose connection, your hardware won't draw power and short-circuit itself when it gets wet. If a leak does occur, you'll just have a bit of a mess, and you'll need to dry out whatever parts got doused. However, a clever little gadget that's just turned up at **www.aquatuning.co.uk** can tell if your system will leak without even filling it with coolant.

The Dr. Drop pressure tester, by Aqua Computer, is essentially an analogue pressure gauge. Critically, it can be hooked up to your water-cooling loop using a standard G1/4in fitting, plus it has a small hand pump that connects at the other end. The contraption works by adding pressure to your water-cooling loop using the pump, and then showing the resulting pressure on the gauge. The idea is that, if there's a leak somewhere in the system, the pressure will drop as air will be escaping.

It's an extremely handy device, as it means the most obvious leaks can be eliminated at the start, and without having to power on your pump first with an ATX jumper, then dealing with potential puddles of coolant and having to dry your hardware. You should still continue to leak-test your water cooling system, though, as once it warms up, tubing and components can expand, and the Dr. Drop can't help you here. You'll also need to thoroughly leak-test your water cooling system for slow leaks once it's powered on too.

This month, we've taken a look at how to use the Dr. Drop for leak testing on p106. **CPC**

The Dr. Drop is essentially an analogue pressure gauge

Antony Leather is Custom PC's modding editor @antonyleather

How to
Make an acrylic side panel

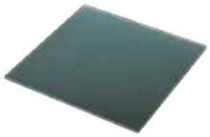
Want your side panel to show off your PC building skills? Antony Leather shows you how to create a see-through one

TOTAL PROJECT TIME / 3 HOURS

If your PC is packed with great-looking hardware, lights or water-cooling gear, it seems a shame to hide it all behind a solid side panel, and most windowed side panels will only show off a section of your handiwork too. Recently, though, manufacturers such as In Win have introduced completely transparent side panels made from glass or acrylic, and they look fantastic, showing off every detail of your case's interior.

Sadly, very few cases offer clear side panels at the moment, but it's very easy to create one yourself. If your case uses side screws to hold the current side panel in place, such as some of Lian Li or Raijintek's cases, then it's particularly easy, but you can also do it with thumb screws. We'll be looking at both methods – all you need is a Dremel or jigsaw, a drill and some acrylic.

TOOLS YOU'LL NEED



Acrylic sheet / www.ebay.co.uk

Dremel or jigsaw / Most hardware stores

Drill and drill bits / Most hardware stores

Masking tape / Most hardware stores

2,000-grit sandpaper and file / www.amazon.co.uk

1 / CHECK MOUNTING LOCATIONS

Most cases have guide rails for side panels, which are ideal for mounting your acrylic panel. You'll need to remove any obstructions, such as pins or flanges that hold the panel in place, with a Dremel and cutting disc, plus a file to smooth the edges, so the panel sits flush.

2 / MEASURE FOR ACRYLIC

The acrylic panel needs to match your case's side opening, covering any rails; it will essentially sit in the old panel's location. Measure the area so you can purchase the correct size of acrylic sheet.

3 / MARK UP ACRYLIC

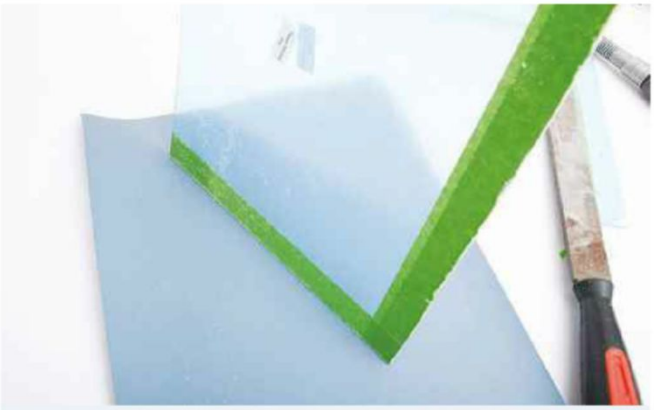
Using your measurements, mark up the acrylic by applying masking tape over the lines you'll be cutting. This procedure enables you to draw on the acrylic, and the tape will also protect against any slips you make with your cutting tool.

4 / CUT TO SIZE

Use a jigsaw, or a Dremel with a lightweight cutting disc, on a slow speed to cut the acrylic – the latter is important to prevent the acrylic from melting.

5 / FILE EDGES

Use a metal file to start smoothing down the rough edges after cutting. File with long, straight movements against the length of the edge, rather than filing from side to side in small sections.

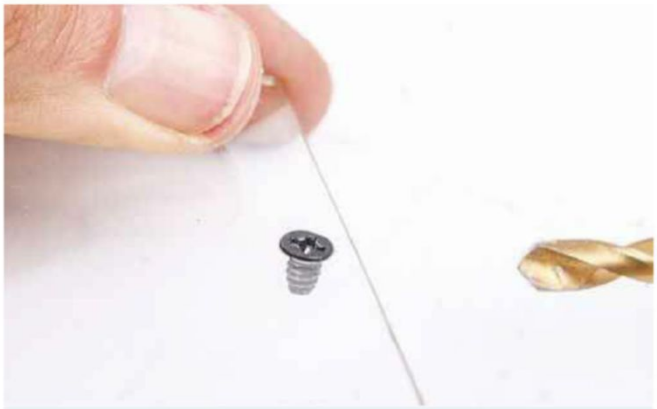


6 / SAND EDGES

Now use 2,000-grit sandpaper to smooth off the edges – this process may take a few minutes, but it will result in smooth edge that generally eliminates the need for flame polishing.

7 / DRILL HOLES

The panel needs a screw or thumbscrew in each corner to mount it securely to the side of the chassis – you can't use rear thumbscrews. Use the appropriate drill bit for your screws' threads to drill holes in the acrylic – you may be able to use your original side-panel screws here.



8 / CREATE COUNTERSUNK GROVES

If you want the screws to sit flush with the acrylic, you can use countersunk screws. Using a slightly larger drill bit, cut into the acrylic about two thirds of the way, or far enough to let the screw sit neatly in the recess.

9 / FIT SIDE PANEL TO CASE

You can use M3 screws to secure the side panel, drilling through the panel with a slightly smaller drill bit and allowing the screw to tap into the case. Alternatively, your side panel may already use screws that you can reuse with your new side panel in the same way. CPC

How to

Leak-test water cooling and add a flow meter

Antony Leather shows you how to prevent leaks from your water-cooling system, and add a flow meter to it

TOTAL PROJECT TIME / 24 HOURS

While water-cooling your PC can be expensive, time-consuming and complicated, the fear of leaks is often the main culprit for preventing some people from taking the plunge. It's a well-founded fear, of course; water and electricity don't make the best of friends, and when that argument takes place inside your PC, putting all your hardware at risk, it's no surprise that water cooling is still a niche hobby.

It's a growing one, though, as it's easier and safer than ever before. Pump failure is extremely rare and, even if it does occur, your PC will likely just switch itself off when it gets too hot. Also, by leak testing with the new Dr. Drop pressure tester, and adding a flow meter, you can practically eliminate leaks before even filling the system, and get an alert if the pump fails too.

TOOLS YOU'LL NEED

Dr. Drop pressure tester /
www.aquatuning.co.uk

Flow meter /
www.aquatuning.co.uk

Water cooling fittings /
www.watercoolinguk.co.uk

1 / BUILD WATER-COOLING LOOP

Start by building your water cooling system into the case. You want the loop to be as complete as possible – don't leak-test it outside the case, dismantle it and then install it inside the case, or you risk the entire loop being untested.

2 / DETACH ONE TUBE

In order to fit the Dr. Drop pressure tester, you'll need to detach one fitting and connect that tube to the Dr. Drop. Ideally, this fitting should be in a location that isn't in the path of high-pressure coolant. The top of a reservoir is a good place.

3 / BUNG THE THREAD

If you have no reservoir, or if your reservoir's fill cap thread is too large, you'll need to detach a length of tubing. Connect the Dr. Drop to the other end, then use a G1/4in bung to block off the empty port.

4 / ATTACH PUMP SECTION

The Dr. Drop's little hand pump section isn't attached to the pressure meter out of the box, so you'll need to attach it. The pump also needs to be detached when you take a pressure reading, as it isn't airtight. Connect it to the pressure meter and practise removing it a few times.

5 / ATTACH FITTING TO DR. DROP

To attach the Dr Drop to the loop, simply screw a G/14in fitting to the thread at the side. You'll then be able to connect it to your reservoir, or a temporarily open part of your water-cooling loop.

6 / CONNECT TUBING

Connect the tubing to the fitting on the Dr. Drop and make sure it's airtight by locking down any compression fitting collars. Double-check all the connections to make sure they're screwed tightly together.

7 / PUMP UP TO 7PSI

Most water-cooling pumps dish out up to 6psi, so applying 7psi with the hand pump is a good test – it won't need more than a couple of pumps to reach this pressure.

8 / REMOVE PUMP AND CHECK PRESSURE

The pump uses a bike tyre valve to cut off air once it reaches the correct pressure. As the pump isn't airtight, you'll need to remove it quickly. The pressure shouldn't drop below 6psi, and you can use the tester to find leaky components – the fittings may just need tightening.

9 / CHOOSE FLOW METER

To warn you if your pump has failed, you can use a flow meter with an RPM readout cable. It isn't necessary to have a fancy one with a spinning wheel – you just need to be able to connect it to your motherboard or fan controller.

10 / FIND FLOW METER LOCATION

Some flow meters can be attached in-line with tubing, while others need to be attached to a drive bay or mounted in the case. If you have nowhere obvious to mount a separate flow meter, consider using an in-line one and placing it near your fan header.

11 / INSTALL FITTINGS

In-line flow meters have two G1/4in ports that you'll need to occupy with fittings of your choice, or you can use a male/male threaded adaptor to connect it directly to a component.

12 / CONNECT RPM LEAD

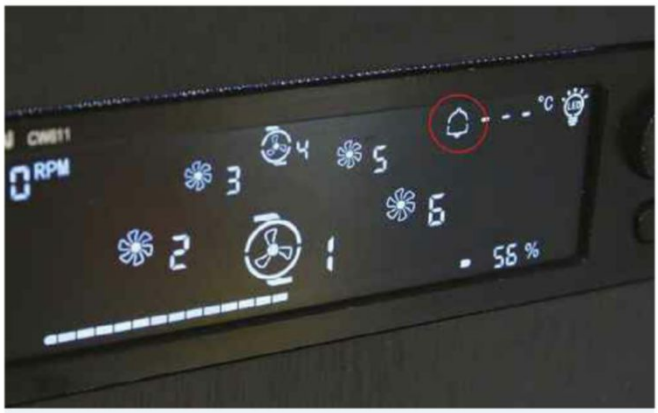
Most flow meters have an inlet and outlet, and just require two G1/4in fittings. You're then just left with the simple task of attaching them and connecting the RPM lead to your motherboard's fan header.

13 / POWER ON SYSTEM

With your system leak-tested, power on the system and check that the flow meter is working; it should have a rotating section inside it.

14 / CHECK FAN CONTROLLER

You may be able to set your motherboard to report a zero RPM reading, but if not, most digital fan controllers have a function with an alarm. Make sure to set the input to a flow meter setting.



15 / SET ALARM

The Lamptron CW611's alarm can warn you of a zero RPM reading, or a zero litres-per-hour reading if you have a flow meter. Test it by setting the alarm and momentarily switching off the pump. The alarm should sound, with a bell symbol showing. CPC

Folding@Home

Join our folding team and help medical research

MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE
JaredPaulsen	30000
oli123456789	30000
DEAD-DODO	40000
ARK101	80000
NickCPC	90000
dumbdodo	100000
richardjohn22	100000
thecrazyeyes	100000
Goldmaster	300000
The_Notorious_ Pizza_Boy_(Mike2)	300000
trma97	500000
alces	600000
Mr_Blue_Jam	600000
mar_duke	700000

USERNAME	POINTS MILESTONE
ShavedCloaca	700000
john251282	800000
Nex79	800000
anadir	900000
Pickles96	1000000
Sean_Fletcher	1000000
Tcullen21	1000000
the_kille4	1000000
CCHS	3000000
Lunnbow	3000000
p1ngu_666	3000000
PatStar	3000000
shadybk	4000000
Anonymous	5000000

USERNAME	POINTS MILESTONE
mort6dav3	5000000
elspuddy	6000000
LEACHIE007	6000000
Ubereme	6000000
kiiight	7000000
smiler	7000000
Ganey	8000000
jonesd98	8000000
PCEnthusiastUK	8000000
wew	8000000
Aardwork	10000000
dazlanc_101	10000000
MarkVarley	10000000
QuasarGreg	10000000

USERNAME	POINTS MILESTONE
Tango_Echo_Alpha	10000000
ZeDestructor	10000000
Arthur_Buse	20000000
Mem	20000000
Sparkymatt	40000000
Trunkey	40000000
SirBenjaminNunn	90000000
madmatt1980	200000000
apeman556	400000000
Lordsoth	800000000
PC_Rich	800000000
Scorpuk	1000000000

WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from **http://folding.stanford.edu** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers online at the **www.bit-tech.net** forums.

TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	DocJonz	2,755,689,744	207,108
2	Nelio	2,720,035,769	242,555
3	HHComputers	2,296,506,529	62,193
4	piers_newbold	1,127,567,850	64,668
5	Scorpuk	1,056,669,562	37,661
6	coolamasta	946,940,506	186,894
7	PC_Rich	819,961,012	91,409
8	Lordsoth	818,216,280	109,070
9	StreetSam	571,113,589	90,251
10	Slavcho	569,222,153	39,979
11	Laguna2012	560,904,209	30,527
12	johnim	534,006,305	83,261
13	Dave_Goodchild	466,657,304	120,159
14	The_M2B	445,875,884	67,412
15	Desertbaker	436,783,025	26,191
16	apeman556	414,423,235	33,487
17	KevinWright	375,364,289	35,077
18	Dickie	297,523,678	28,381
19	daxchaos	293,529,035	9,444
20	TheFlipside	265,828,217	26,832

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	HHComputers	6,066,879	2,296,506,529
2	DocJonz	5,463,583	2,755,689,744
3	PC_Rich	3,005,897	819,961,012
4	Scorpuk	2,123,955	1,056,669,562
5	Lordsoth	2,095,692	818,216,280
6	piers_newbold	1,969,272	1,127,567,850
7	Unicorn	1,360,777	181,111,489
8	apeman556	1,146,504	414,423,235
9	Trunkey	934,631	49,008,119
10	madmatt1980	895,471	212,282,028
11	Nelio	869,499	2,720,035,769
12	Desertbaker	771,798	436,783,025
13	daxchaos	770,676	293,529,035
14	Laguna2012	656,443	560,904,209
15	BeezaBob	576,393	221,194,292
16	KevinWright	494,903	375,364,289
17	SirBenjaminNunn	431,960	97,612,531
18	Roveel	428,411	264,154,758
19	TheFlipside	352,486	265,828,217
20	Slavcho	329,551	569,222,153

Readers' Drives

Star Trek Beyond

Professional PC modder Bill Owen built this USS Enterprise-themed PC by cannibalising parts from Star Trek play sets, building a custom water-cooling loop and doing a lot of airbrushing

/MEET THY MAKER

Name Bill Owen
Age 48
Location Minnesota, US
Occupation Professional PC modder
Main uses for PC Gaming
Likes Science fiction movies, hot rods, choppers, old VWs, case Labs
Dislikes All-in-one coolers, lazy people, copycat manufacturers

CPC: What originally inspired you to build this project?
Bill: This PC was built for my friend, Sgt Will Hoover. He's a huge fan of Star Trek and he loves PC games. He's currently at the Walter Reed National Military Medical Center in Bethesda, Maryland, USA, where he's recovering from taking five bullets while he was protecting a British officer in Afghanistan.

We agreed to keep the Star Trek theme subtle and clean – it's more focused on the USS Enterprise ship than anything else in Star Trek.

I loved the idea of painting a diagram of the original ship on the side. The custom chassis shroud shows the Enterprise ship from the Next Generation TV series. The scale model of USS Enterprise was given to us by my friend Graham Lovhaug after he heard I was doing the build. I couldn't decide on where to locate the model until the build was finished; this bit is really just for grins and giggles.

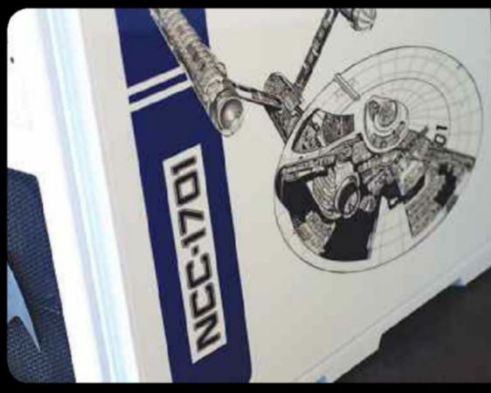
We also agreed that we wanted to pay tribute to Leonard Nimoy, who passed away last year. A picture of his character, Spock, was airbrushed onto the perforated top grille by Brad Galvin. The grille perforations made it challenging for Brad to keep the picture recognisable and to scale though. Brad cursed at me during the entire process, asking, 'Couldn't you have chosen an easier surface to paint?!' All of the custom paintwork and graphics were created by Brad Galvin's paint shop, **http://dirtdesignsgraphic.com**. We decided to call the machine Star Trek Beyond, as the movie is being released this year.

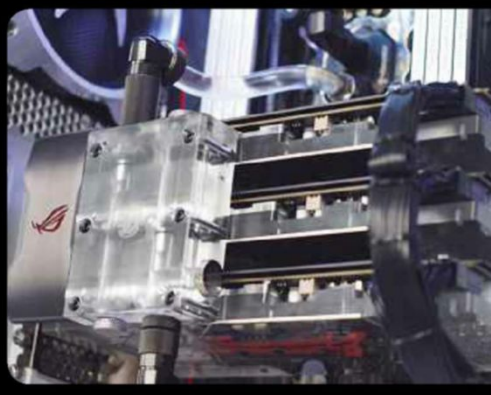
CPC: What other projects have you built for customers?
Bill: The majority of my custom rigs are built for marketing and industry trade shows, but there's a big variety. If you're interested, you can see my builds from the past 14 years on **www.mnpctech.com**

CPC: What difficulties did you come across?
Bill: Creating the large graphic of the USS Enterprise on the side panel required a lot of experimentation. Some portions of the ship were airbrushed by hand over a decal we had printed. Our first application of clear coat was lacquer-based, which ate through the decal for some unknown reason, which we still haven't solved.

We had to redo the graphic and switch to an enamel-based clear coat to get round this problem.

CPC: How did you make the Warp Core section?
Bill: I cannibalised the Warp Drive from a Star Trek Generations Playmates set I found on Craigslist for a song. I modified it to show power and hard drive LED activity, and you can slide it in and out of the case via a drive cage.





CPC: What tools and machinery did you use?
Bill: The clear side panel window and rear fan grille were CNC machined by my company, Mnpctech.com. Every other part was handmade. People are always

SEE THE FULL PROJECT LOG:
http://tinyurl.com/TrekTribute

amazed that I make some parts by hand rather than having them CNC-machined, but you don't need to use machines for every job.

CPC: What media interest has this project attracted so far?
Bill: Corsair shared the photo of Graham's scale USS Enterprise suspended in front of the Corsair 32GB Dominator DDR memory we used. Should I be propping up toys in all of my future builds? I promise this will be the last one!

CPC: How long did it take you to finish building this project?
Bill: It took a few months, because halfway through the build process, we decided to upgrade the graphics cards to Zotac GTX 980 Ti AMP Extreme cards, which in turn required waiting for Bitspower to make new waterblocks for them. As far as I'm aware, Bitspower is the only source for these waterblocks.

CPC: What did you learn from the build process?
Bill: The Phanteks Enthoo Luxe might be a full tower, but it's still a little cramped for managing the cables for triple SLI graphics cards and eight SSDs.

Unless, of course, you're fine with letting everyone see your cables in full view through a clear side panel, which I'm not.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?
Bill: Yes, I'm happy with the end result. It's a tight and clean build, and I love the overall paint scheme. We wanted to keep every aspect of this build tasteful. I love how the edges of the Phanteks Enthoo Luxe's top and front panel are illuminated with blue.

The clear side panel turned out great too, with the interior being illuminated with RGB lighting. In retrospect, I should have added a bleed valve to the top of the Bitspower GPU bridge, though, to help bleed air while I'm filling the loop. Otherwise, I wouldn't change a thing. CPC

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to **www.bit-tech.net** and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

SYSTEM SPECS

CPU Intel Core i7-5960X
Graphics card 3 x Zotac GeForce GTX 980 Ti AMP Extreme
Case Phanteks Enthoo Luxe
Memory 32GB Corsair Dominator DDR4
Motherboard Asus Rampage V Extreme
Storage 8 x Samsung Evo 850 SSDs
PSU SilverStone 1,500W
Cooling Koolance CPU black acetal waterblock, 3 x Bitspower AMP Extreme GPU waterblocks, Bitspower GPU bridge, 360mm Darkside Radiator, 240mm Darkside Radiator, Koolance x2 Reservoir, 2 x D5 Laing pumps, combination of Koolance and Primochill compression fittings, Mnpctech 0.5in (OD) PETG tubing

Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.

Mayhems coolant and dyes

VALUE £50 inc VAT / **MANUFACTURER** www.mayhems.co.uk

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors.

As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

JAMES GORBOLD / HARDWARE ACCELERATED

CHANGING TIDES

The graphics card, rather than the processor, now defines the modern PC, argues James Gorbold

As the PC turns 35 this month, it continues to evolve to meet new challenges, diversifying into an even greater plethora of form factors and designs optimised for different applications. Nowhere is this evolution more apparent than in the GPU market, which is not only taking an increasing share of the cost of modern PCs but still advancing technologically at an incredible rate.

This summer alone has seen AMD unveil three new Radeon gaming GPUs and 11 Fire Pro professional cards, while Nvidia has launched several new GeForce gaming GPUs, plus six Quadro and Tesla professional cards, with another two more Quadro cards already announced and due next month. The sheer number of new cards and the huge variety of price points (ranging from £99 to £7,749) and applications they target is simply staggering, all the way from casual gaming, to VR, machine learning and every job in between.

The GPU is now a fundamental component of the PC. After all, for games, the most important component is the graphics card, and the same is the case for graphics workstations, with video workstations and servers fast going that way too. About the only area that graphics cards haven't penetrated is audio workstations, which are still very CPU dependent.

Of course, it's still important to get the right balance of components when upgrading or building a new PC, with a solid state drive being one of the best upgrades you can make to an aging system, making it feel much more responsive than a mechanical hard drive. However, many of the traditional core components of the PC are being left behind.

For instance, CPUs have barely become any faster from generation to generation over the past few years, and the real-world benefits of quad-channel RAM over dual-channel RAM, or DDR4 over DDR3 is extremely slim. In contrast, graphics cards continue to make giant leaps in performance, with both AMD and Nvidia delivering new models of GPU that outperform their previous-generation chips by at least 30 per cent.

As such, I think it's fair to say that the graphics card currently dominates and defines the PC market. The effects of this seismic change can be seen in the massive restructuring and layoffs that Intel has been undergoing for the past few months, including the wholesale rewriting of roadmaps. Intel's share price is still very healthy, but while revenue continues to grow, profit is barely up on a few years ago.

> The sheer number of new cards and price points (ranging from £99 to £7,749) is simply staggering

Meanwhile, the market leader in gaming and professional graphics, Nvidia, seems to be going from strength to strength, with its share price more than tripling in the past three years as the result of some very healthy profit taking. This sea change should also be an opportunity for AMD – although its graphics card market share isn't as strong as that of Nvidia, this situation could change with the right mix of new products.

I'm certainly not suggesting that Intel is going anywhere. Intel is, after all, still one of the world's largest tech companies with fingers in many pies, but what I do believe is that the x86 CPU that's dominated the PC for the past 35 years is no longer the dominant component.

In fact, I'd go as far as suggesting that the CPU is no longer the primary processor in most PCs, but a co-processor to the graphics card, with the latter contributing the most noticeable chunk of performance, and consuming the lion's share of your wallet. **CPC**

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

msi

1st VR READY

SHATTER DESKTOP PERFORMANCE CLICHÉ

GAMING G SERIES

ALTER YOUR REALITY

THE LATEST GRAPHICS WITH 40%+ PERFORMANCE BOOST

intel CORE i7 inside

LATEST 6th GEN. INTEL® CORE™ i7 PROCESSOR	WINDOWS 10 HOME / WINDOWS 10 PRO
GEFORCE® GTX 1080 / GTX 1070	VR READY	120HZ 5MS DISPLAY (OPTIONAL)
COOLER BOOST TITAN	MECHANICAL BACKLIT KEYBOARD	CHERRY MX SWITCH
DRAGON CENTER	X BOOST	STEELSERIES ENGINE 3	NAHIMIC 2	WTFAST

INTEL INSIDE® . EXTRAORDINARY PERFORMANCE OUTSIDE.

WHERE TO BUY

SCAN computers — Scan Computers, www.scan.co.uk, 0871 472 4747

box.co.uk — Box Ltd, www.box.co.uk, 0121 202 0030

amazon.co.uk

ebuyer.com

*Performance result may vary on different configuration. Product features and specifications may vary by model.

Intel, the Intel Logo, Intel Inside, Intel Core, and Core Inside are trademarks of Intel Corporation in the U.S. and/or other countries.

GAMING.MSI.COM

SCAN 3S

scan.co.uk

NVIDIA TITAN X at Scan

- New ground breaking Pascal architecture
- Superior power and performance with 10.9 teraFLOPS
- Enjoy ultra-high 4K resolution at over 60 fps
- Super-fast raw processing power with 3,584 cores
- Next-level memory performance with 12GB GDDR5X

Available in 3XS SYSTEMS

Scan Platinum Partners

THE ULTIMATE NVIDIA TITAN X

The NVIDIA TITAN X is the ultimate graphics card. Whatever you're doing, this groundbreaking GPU gives you the power to accomplish things you never thought possible. Powered by the groundbreaking NVIDIA Pascal™ architecture, TITAN X is a powerful combination of brilliant efficiency, stunning design, and industry-leading performance.

CORSAIR VENGEANCE LED SERIES HIGH PERFORMANCE

Corsair Vengeance LED Series DDR4 memory modules are designed to provide a unique look with vibrant LEDs and a precision engineered light bar, created specifically to pair with the design themes of most motherboards and PC gaming components.

INTEL® CORE™ I7 6800K 6TH GENERATION PROCESSOR

Enjoy unparalleled performance in content creation applications with the NEW Intel® Core™ i7 processor Extreme Edition with up to 10 processor cores, 25MB of Intel® Smart Cache, 40 PCIe® 3.0 lanes, DDR4 2400MHz memory support and the NEW Intel® Turbo Boost Max Technology 3.0.

Spec your perfect PC at **www.scan.co.uk/3xs** and we'll build it just the way you want. Choose from thousands of components, including overclocked CPUs, graphics cards and gaming laptops.

01204 47 47 47